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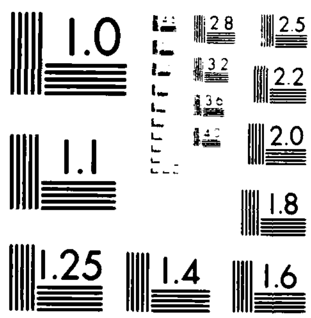

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A SAC B-52 AIRCREW SCHEDULING MODEL USING ICAM'S IDEF METHODOLOGY

John M. Moore, Captain, USAF
Randall D. Whitmore, Captain, USAF

LSSR 31-82

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This research analyzes the SAC B-52 flight aircrew training scheduling process as a system. Operational planning for aircrew resource use maintains an essential importance in the attainment of a unit's mission. Using operational requirements and maintenance capability, unit planners develop aircrew training schedules designed to assure mission-ready crews remain prepared to perform the wing's primary mission. The study reviews the aircrew scheduling system problem history as it evolved from an art to a science using a systems perspective. Numerous historical and recent attempts at computerizing the system also receive attention. Current Decision Support System (DSS) concepts plus the requirements for a data base and data base management provide the overall research framework. Using Integrated Computer-Aided Manufacturing (ICAM) IDEF (ICAM Definition) modeling procedures, the authors depict the functions and their relationships of the B-52 aircrew planning system. This effort demonstrates IDEF as a usable modeling technique as a first step towards a complete computer-aided decision support system. Once a DSS exists for the unit under study, then command attention can focus on the adoption of successful procedures to other units and differing missions.

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A SAC B-52 AIRCREW SCHEDULING MODEL USING ICAM'S IDEF METHODOLOGY

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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and

Captain Randall D. Whitmore

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

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COMMITTEE CHAIRMAN

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INTRODUCTION

Background

"A schedule is a timetable for performing activities, utilizing resources, or allocating facilities [Chase and Aquilano, 1981:425]." Scheduling, then, is the process of coordinating and adjusting these activities, resources and facilities.

Scheduling is not a new problem, nor is it a problem peculiar to a specific set of circumstances. Man has always had to make scheduling or sequencing decisions, even if this only involved the arranging of daily activities. Scheduling consists of decision-making and the allocation of resources to particular activities. It follows a planning process that decided the scheduled activity is actually necessary (Bush, 1978:3).

Within the Strategic Air Command (SAC) the aircraft and aircrew scheduling process entails the coordinating and adjusting of flight and ground training events, and planned and unplanned aircraft maintenance (the necessary activities); crew members, maintenance personnel, aircraft, equipment, and allocated flying hours (the resources); and buildings, hangars, and classrooms (the facilities).

A typical SAC B-52 wing organization contains echelons of authority (see Fig. 1.1). A wing commander coordinates and controls two deputy commanders: one for operations and one for maintenance. Operations aircrews are organized into squadrons, usually a bombardment and a refueling. SAC Regulation (SACR) 60-9, Planning and Scheduling Aircrew and Aircraft Usage, levies the scheduling of aircrew activities upon the operations commander and his staff (1980:p.2-1). The key staff member responsible for the development of training plans for all tactical aircrew personnel is the unit director of training (DOT). No other staff agency may schedule aircrews for any activity without coordinating with the appropriate DOT mission development branch schedulers. The scheduling branch personnel, assisted by the bombing/navigation branch, defensive systems branch, and tactical squadrons, develop the mission training packages designed to meet unit training objectives within the allocated flying time received from SAC.

Operational planning for aircrew resource use is essential to insure attainment of a unit's mission. Using operational requirements and maintenance capability, unit planners develop schedules to assure that mission-ready crews remain prepared to perform the unit's primary mission (SACM 51-52, Volume 1, 1980:p.2-2). Crews remain ready to perform the unit's mission by flying an adequate number of sorties containing enough diverse training events to maintain flying proficiency. Various skill levels exist among aircrews which require the balancing of sortie packages. Requirements for

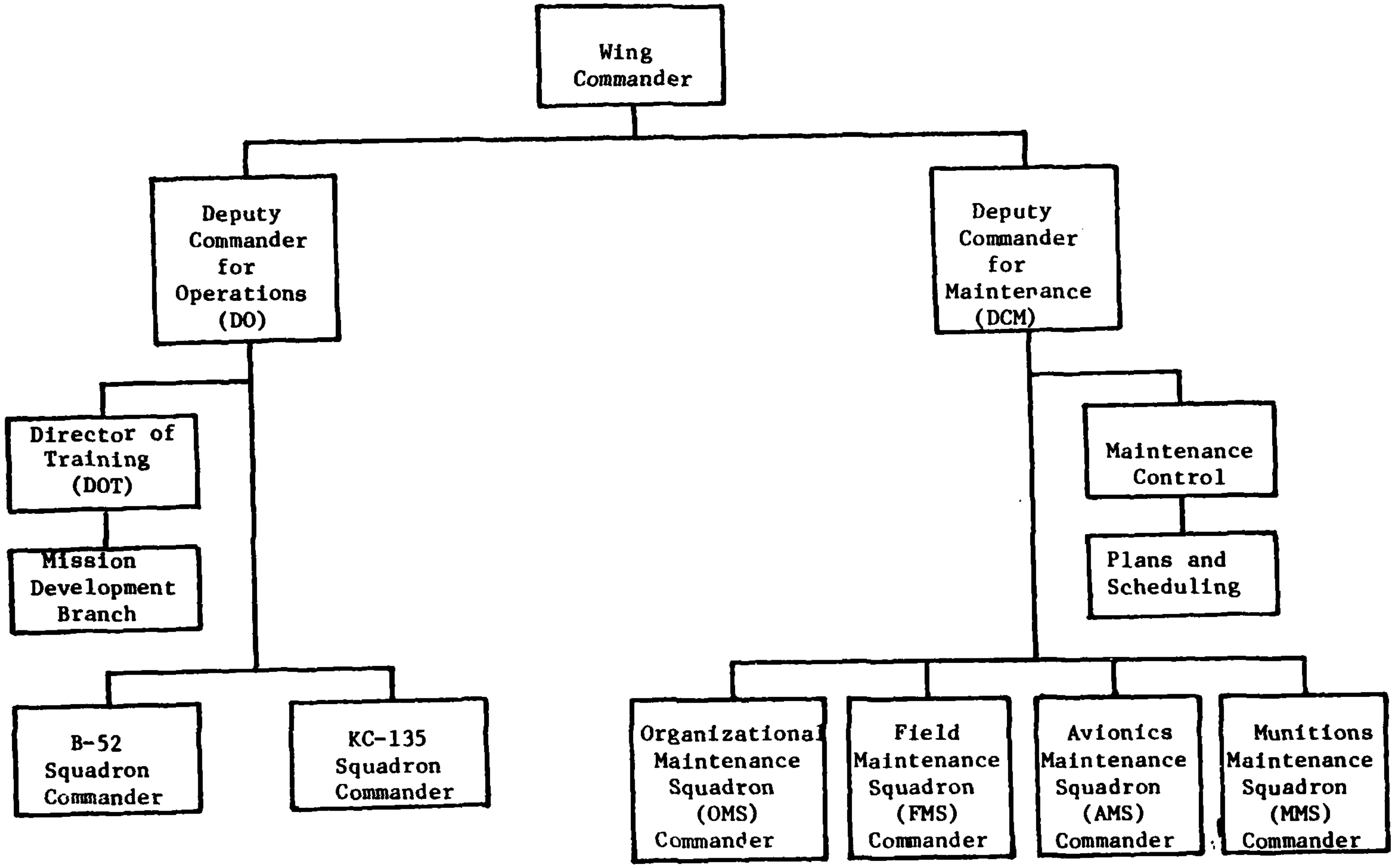

Fig 1.1. Wing Formal Structure
(Berman, 1975:6)

sortie allocation include: planning nonmission-ready qualification flights, training of navigators to the more skilled radar navigator position through the navigator upgrade program, improving copilot skills to those of a pilot with pilot upgrade program sorties, and insuring staff and instructor personnel remain proficient. Schedules allow for the annual evaluation of flying expertise as required by regulation and conducted by highly experienced standardization evaluation crews. Additionally, evaluation personnel use schedules as a decision-making aid when planning periodic no-notice inflight evaluations of unit personnel proficiency.

Within a SAC B-52 wing, the scheduling function insures crew members obtain and maintain flying proficiency. Subordinate to the flying activities are ground training requirements designed to supplement and enhance both flying and basic military skills. Other factors requiring a timetable include sufficient time available for crew rest, physiological training in the altitude chamber, and flight physicals. Mission development branch personnel use schedules to assign mission-ready crew members to ground alert duty in support of aircraft forming one leg of the Triad - the quick-reaction strategic forces defending the United States.

Unit planning is based on a quarterly period with monthly, weekly, and daily refinements. These four, closely related but separate phases start with the receipt of the first information affecting the unit for the training cycle. Operations staff personnel compile data for planning from numerous sources.

Approximately seven weeks before the quarter begins, SAC provides each unit with the Flying Program Document, which gives the unit sortie requirements and flying hour allocations. Unit alert commitments also come from SAC. Higher headquarters peacetime air operations schedules arrive at the unit not only from SAC, but from its numbered air force and parent air division. About six weeks before the next quarter begins, unit schedulers attend a conference to negotiate and obtain committed simulated bomb release times on joint use ranges. Unit schedulers confirm air refueling tracks and refueling unit support via a planning document which contains all authorized refueling resources for the quarter. SACR 60-9 requires operations squadron commanders to provide the unit planners with a proposed six-month leave request for all the crews/crew members within their squadron. The operations system management branch generates data concerning aircrew/staff evaluation requirements (i.e., general and instrument flying qualifications, simulator qualification, physicals, and physiological training) and supplies it to the mission developers. The standardization evaluation division provides a planning input by the fifth workday of each month, identifying their desired evaluation schedule for the following month. They also complete preparatory coordination for the second subsequent month. Other unit staff agencies supply the DOT with their alert and flying availability, leave, and temporary dutyschedules before the 15th of the month preceding the month being planned.

The current scheduling method actually requires many man-hours of attending conferences; sorting through program documents, higher headquarters messages, various forms, and computer printouts; and making telephone calls to compile planning data. Once the data compilation is complete, the individual/crew leave, temporary duty, qualification checks, and training requirements; and the air division, numbered air force, and SAC taskings are manually posted to the master programming board (Mitchell, 1980:p.2-1). Crew resources are then matched with training/tasking based on their availability for the period being posted, usually a week or month.

The unit scheduler makes these decisions within a framework of formalized guidance and procedures and informal unit policies. Scheduling is not a static process which adheres to no deviations from the original plan. Numerous unpredictable factors usually arise which result in the need to partially or even completely rework the schedule. Typical factors such as bad weather, unplanned maintenance, strategic training range changes, air refueling changes, and aircrew sickness lead to situations requiring short notice changes to the particular segment of the schedule involved. The scheduler adjusts the schedule to "crisis manage" the unforeseen event, usually without the benefit of the overall perspective maintained during the schedule formulation. The art of "satisficing" is practiced as the scheduler attempts to find someone--anyone--to fill a particular sortie (Egge, 1978:6). Little consideration is given to whether or not the individual picked would be the best choice under the circumstances. Within the current system, these short notice changes may result in crews or crew members flying sorties that provide them with less proficiency training than originally planned (Berman, 1975:15).

Problem Statement

Chapter 2 presents numerous efforts at modeling and writing computer programs for the aircrew scheduling process. The focus of these efforts has been to better understand this process, simulate it, and assist schedulers in developing schedules. However, the majority of these attempts has been too general and all encompassing; therefore, they have not been widely implemented. Those that have been implemented, such as the "Automated Missile Operations Management System" (Bush, 1978) at Whiteman AFB, Missouri, have been developed specifically for the unit.

In October 1981, Headquarters SAC's Management Systems Development Branch received approval to purchase microcomputers and optical mark scanners, and is currently placing them in each SAC wing (Mitchell, 1981). The microcomputers and optical mark scanners are to be used in the scheduling process to coordinate and manage activities and resources (Mitchell, 1981). According to Mitchell, the wing level microcomputers will be connected to central computers at Headquarters SAC and each numbered air force. At this level they can be used to help "crisis manage" wing level problems and needs (1981).

For the wings to effectively and efficiently use this new capability, each will need to develop its own model, computer program, and data base requirements (Balachandran and Zoltners, 1981:812). This research attempts to build a complete functional model of SAC B-52 aircrew scheduling for the 28th Bombardment Wing at Ellsworth AFB, South Dakota, as the initial step in a realistic and practical application of computer technology to the aircraft and aircrew scheduling problem.

Justification

The complexity of the scheduling process has been shown. Many man-hours are exhausted daily in manually coordinating and adjusting a schedule (Berman, 1974:vi; Mitchell, 1981:3; and Boyd and Toy, 1975:3). Often the courses of action taken are not the best ones available because of a lack of clear cause and effect relationships, and the availability of current information (Mitchell, 1981:3; and Fallon, 1980:19). So far these and other problems involved in the scheduling process have eluded a satisfactory solution.

A major attempt (Berman, 1974 and 1975) was made by the Rand Corporation to develop a "Decision-Oriented Scheduling System" (Berman, 1974) for the Strategic Air Command. One reason this effort failed was it attempted to be a panacea for all of SAC's aircraft and aircrew scheduling problems. During this time frame a new methodology, known as "Decision Support Systems" (Keen and Morton, 1978) and discussed in

Chapter 2, was evolving. The key idea of this information system methodology is that any computer-aided decision-making process must be user and organization (e.g., a wing) specific.

The fact SAC is placing microcomputers and optical mark scanners in each SAC flying wing to assist schedulers indicates their interest in improving decision-making effectiveness in the aircrew scheduling system. However, a model that clearly shows the functional elements, and their informational relationships and needs has not been built for any SAC wing. Therefore, following decision support methodology, a real need exists to construct a model of the aircrew scheduling system for <u>each</u> SAC wing (e.g., B-52G vs. B-52H, B-52H vs. RC-135, KC-135A vs. KC-135Q, etc.).

Scope and Limitations

This research analyzes the SAC B-52 flight and ground training events scheduling process as a system. The focus is on developing a functional model of the system and identifying the necessary information elements for use in decision support. The objective is to eventually establish a complete microcomputer-based decision support system for the scheduling process.

This thesis is limited to B-52 operations scheduling and does not address the maintenance scheduling process, KC/EC-135 scheduling, cost aspects, computer hardware and software decisions, organizational and behavioral aspects of implementing such a system, nor write a computer program for the scheduling system. Furthermore, the modeling process is limited to developing a functional model for only the 28th Bombardment Wing at Ellsworth AFB, South Dakota. Further, an informational model is built for the monthly decision of assigning individuals by name to ground alert duty.

Parallel research has developed a functional model for the SAC B-52 aircraft scheduling process at the 28th Bombardment Wing (Hackett and Pennartz, 1982).

Research Objectives

The objectives of this research are to:

1. Build a SAC wing level functional model of the B-52 aircrew flight and ground training events scheduling system for the 28th Bombardment Wing; and

2. Develop an informational model for the monthly assignment of individuals by name to ground alert duty at the same wing.

Research Questions

This research will answer:

1. What are the functional elements and the informational relationships of the aircrew flight and ground training events scheduling system for the 28th Bombardment Wing?

2. What are the informational needs for the decision to make the monthly assignment of individuals by name to ground alert duty at the 28th Bombardment Wing?

Organization

Chapter 2 covers the aircrew scheduling system problem history as it evolved from an art to a science using a systems perspective. Various approaches at computerizing the system also receive attention. Incorporating the computer and human user into a decision support system for addressing scheduling problems conclude the chapter. The research methodology explained in Chapter 3 outlines the functional and informational modeling approaches that are used to build the models for the SAC B-52 aircrew scheduling problem. Chapter 4 depicts the scheduling functional model. The following chapter contains the informational model for the monthly assignment of individuals by name to ground alert duty. The conclusions and recommendations presented by these authors in Chapter 6 suggest the follow-on work needed to support the SAC aircrew scheduling decision process.

Chapter 2

REVIEW OF LITERATURE

Purpose

A review of the literature reveals extensive research concerning scheduling and the various organizational elements affecting the system. This chapter presents the past research regarding scheduling as a system and associated approaches to improve the manual methods used by aircrew mission development branch managers. A central development towards modernizing the scheduling system involves the use of microcomputers as a bridge to future decision support systems (DSS). The concluding segment of the chapter contains previously published information about the fundamental elements of database systems required for a DSS.

Scheduling System

The universal scheduling problem is how to assure efficient internal Strategic Air Command (SAC) resource allocation by decentralized wings that achieves the highest overall organizational objective (Berman, 1974:2). The perspective of this research focuses on the finite resources available for expenditure by a bomb wing. These include the B-52 bomber aircraft and its required aircrew members. A B-52 requires six crew members: pilot, copilot, navigator, radar navigator, electronic warfare officer, and aerial gunner. The addition of the flying-hour resource provides the framework for the bomb wing's objective to accomplish a required amount of training and operational activity with a given number of the aforementioned assets. The decentralized efforts contribute to SAC's "primary official goal of operating and maintaining quick-reaction strategic strike forces as a credible deterent to war [Berman, 1975:16]."

The majority of the research surveyed approaches the scheduling system problem cognizant of the prime organizational objective. A 1960 study by the Rand Corporation dealing with the appropriate B-52 alert structure and personnel was one of the first articles to investigate the conflicting demands for limited resources (Levine, 1960). Theses written by four students at the Air Command and Staff College addressed the general subject of SAC aircrew scheduling during the mid-1960's (Bott, 1965; Gehrke, 1964; Stewart, 1965; and York, 1964). Gehrke's work provides a look at a scheduling element with a model for the rotation of crews between alert duty and reflex duty in a B-47 wing. Even though the model helped commanders conceptualize the rotations of their crews, the model proved to be of little practical value to the B-52 aircrew scheduling function, largely because of differing operational concepts. Burkepile's research presents a consolidated, explicit description and analysis of the major requirements and scheduling function constraints (1970:7). For the interested reader, the Burkepile thesis serves as an excellent overall view of the scheduling environment which, with a few exceptions, portrays the system in its current form. The terminology, encompassing just what scheduling was, shifted from <u>function</u> to <u>process</u> with the Berman studies (1974 and 1975).

Berman's work formed an integral part of the Rand Corporation's contracted research investigating ways to increase the efficiency of resource allocation at operating hierarchical levels within the Air Force by improving scheduling (Cohen, 1966; Kiviat, 1965; Miller, 1973; Miller, Kaplan, and Edwards, 1967; Pritsker, 1968; Cohen, 1972; Fallon, 1980; and Ewell, 1976). The wing scheduling system model first presented in Berman's 1974 document appears as Figure 2.1. He depicts the complexity of joint consideration of aircrew and aircraft resource flying and alert requirements by wing operations and maintenance personnel using higher headquarters guidelines. The data elements Berman considered as integral to the scheduling process included the total number of maintenance aircraft preparation activities, rules and local conventions, and maintenance crews available to the maintenance scheduler in creation of the monthly maintenance schedule. From the operations viewpoint, the data elements available consist of aircrew mix; rules and local conventions; alert requirements; change-over time; aircrew needs and training; and instructor, staff, and standardization crews. Within the system, negotiations are important when developing schedules because maintenance and operations schedulers consider their different, often

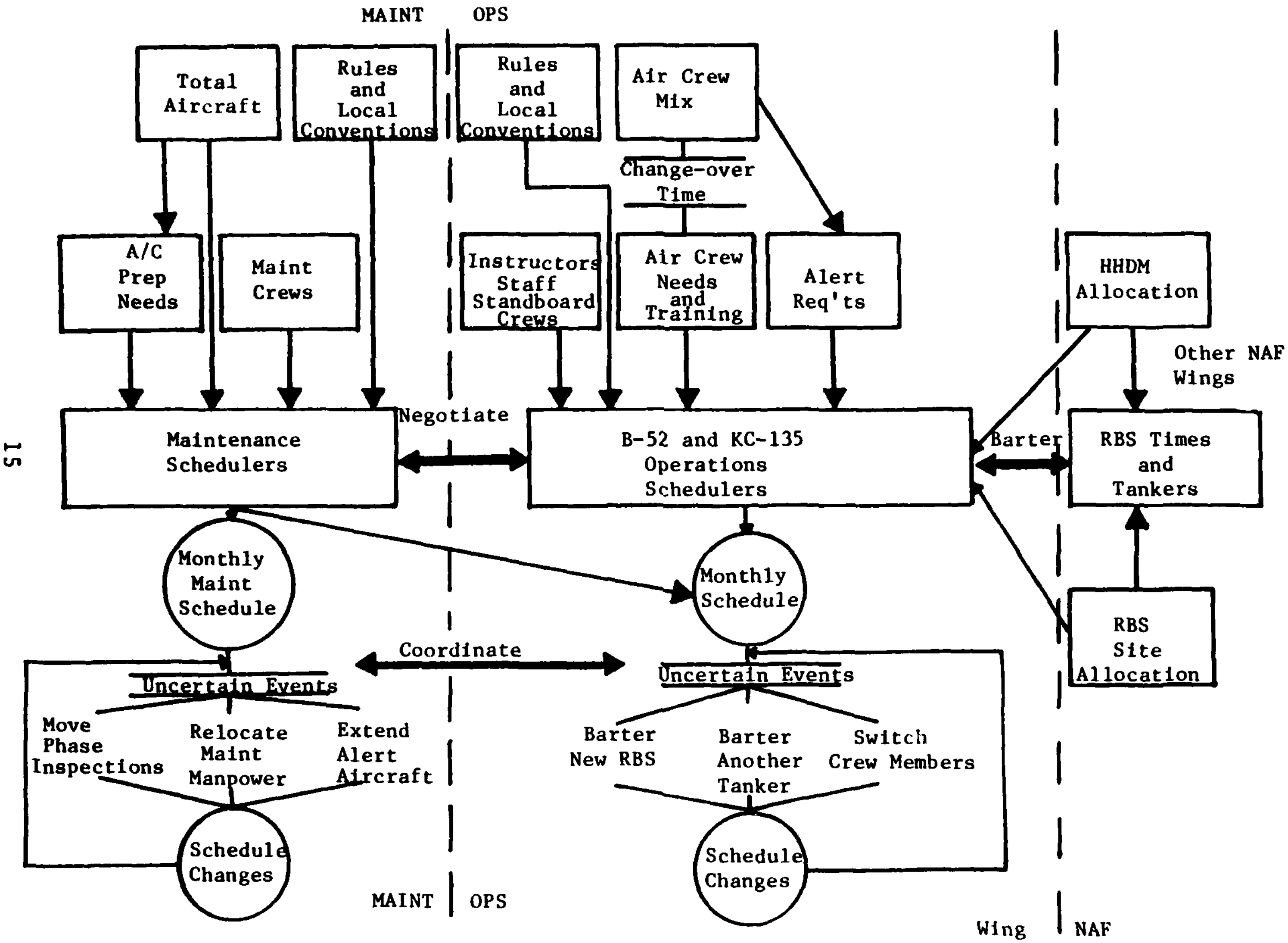

Fig 2.1. The Scheduling Process
[Berman, 1975:13]

conflicting, data element inputs quite parochially. Gibson suggests a method to improve the system would be to consolidate the operations and maintenance scheduling function and make it directly responsible to the wing commander. The data inputs would flow into one central decision center from which the scheduling process would be relieved from the conflict environment which arises between the operations commander and the maintenance commander (Gibson, 1975:41). To date the winds of change have not blown enough to see Gibson's proposal incorporated into the Strategic Air Command's formalized wing organization.

Barnidge and Cioli investigated the possibility of incorporating the scheduling process into a dynamic model. Based upon a System Dynamics methodology, these researchers developed a hypothesized structure of the scheduling process as modeled by the causal-loop diagram in Figure 2.2. When first looking at the figure, it is possible, due to the arrowhead pointers, to observe a directional flow of influence throughout the loop. For example, Barnidge and Cioli hypothesize that wing-directed requirements and higher headquarters-directed requirements provide influential inputs to the total wing requirements which, in turn, directly influence scheduling decisions. Scheduling decisions affect scheduled requirements leading to the accomplishment of the requirements. This final structural link induces change on both total wing requirements and scheduled decisions. The arrowhead pointers used in the hypothesized continuous scheduling cycle reflect

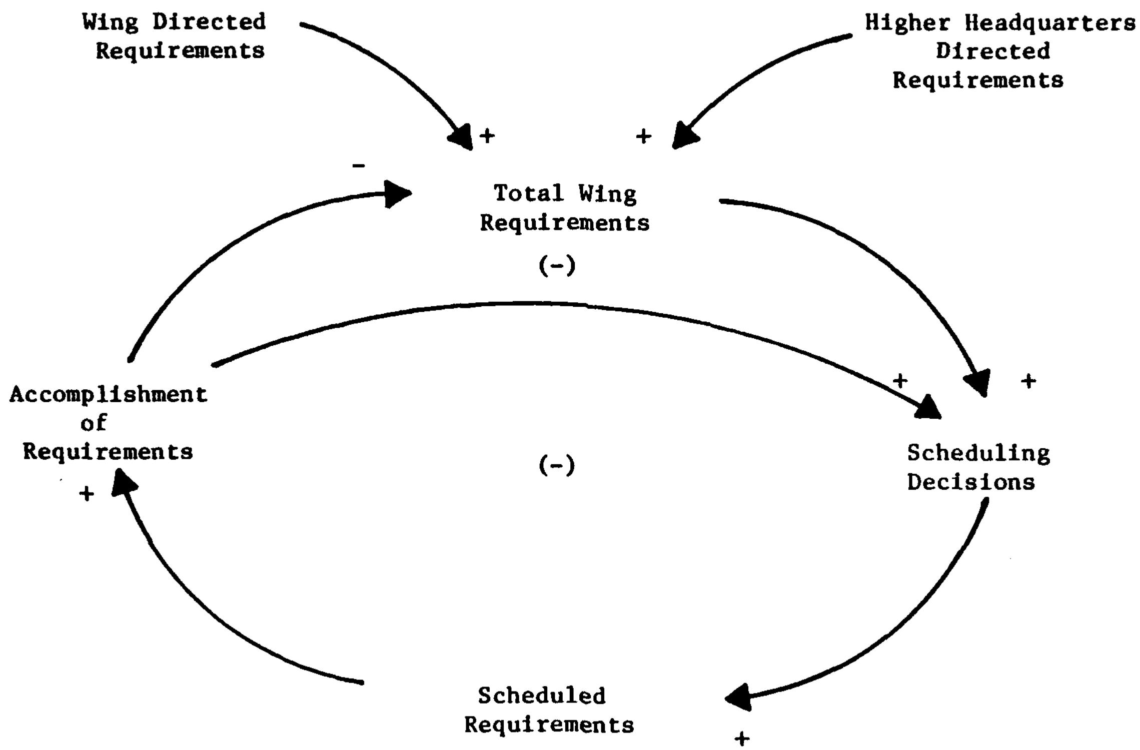

Fig 2.2. Structure of Scheduling Process
(Barnidge, 1978:21)

only directional flows of influence, not the nature of the influence. Causal-loop diagramming uses plus (+) and minus (-) symbols to indicate the influential nature of the system's relationships.

Goodman explains the type of influence that an element has on another can easily be depicted with System Dynamics methodology. Relationships are considered positive (+) if a change in one element causes a similar change in a second variable, i.e., increase-increase or decrease-decrease. A negative (-) relationship occurs when a change in one variable produces the opposite effect in another element, i.e., increase-decrease or decrease-increase. Referring again to Barnidge and Cioli's hypothesized structure in Figure 2.2, observe that increases in wing-directed requirements and higher headquarters-directed requirements increase total wing requirements. Likewise, the total wing requirements increase scheduling decisions, which increase the scheduled requirements and positively affect accomplishment of the requirements. The increase in the requirements accomplished decreases the total wing requirements and scheduling decisions. The overall causal-loop diagram carries a sign indicating the system's nature is negative (stable) or positive (continually reinforcing) (Goodman, 1974:9).

Barnidge and Cioli use a series of single causal loops, similar to the one in Figure 2.3, to build the hypothesized relationships interacting in the wing-level scheduling process depicted in Figure 2.4. Following the System Dynamics

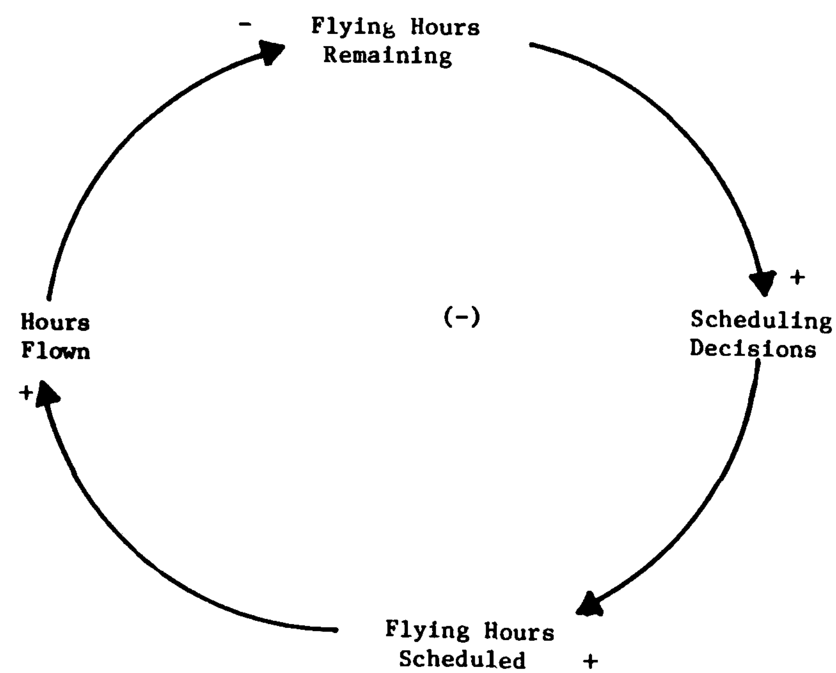

Fig 2.3. Causal Loop Diagram of the Flying Hour Sector (Barnidge, 1974:34)

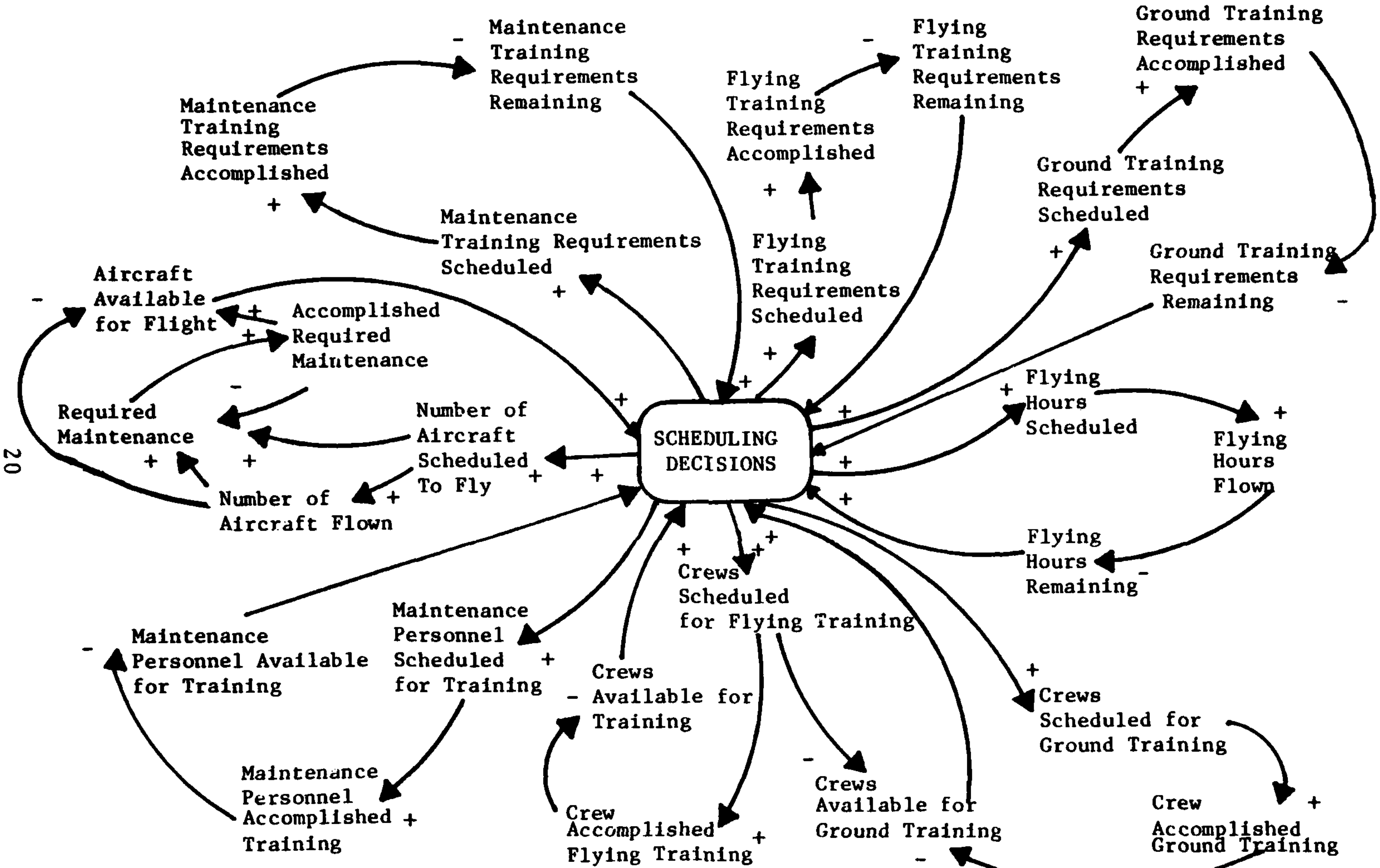

Fig 2.4. Causal Loop Diagram of the Wing Level Scheduling Process (Barnidge, 1974:33)

methodology, the authors use flow diagramming as a means to translate the system modeled in Figure 2.4 into a system of alternating levels and flows (Forrester, 1961:131). "These two basic determinants of a system's behavior are key concepts to the study of systems since they trace the movement of the system from one time period to another [Schoderbek, Schoderbek, and Kefalas, 1980:34]." Through time within a system, "the decision functions are the relationships that describe how the levels control the flow rates [Forrester, 1961:131]." Information paths connect the levels to the decision functions. With the incorporation of information, flow diagramming logically leads to the formulation of equations coupled with one-to-one mapping between the model and the system being modeled. This completes a necessary step towards system modeling through computerization.

Approaches to the Scheduling System Problem

The recommendations contained in the research inevitably support computerizing some aspects of the manual process or developing an entire system to actually produce schedules. The 1974 Berman study recommends the development of a decision-oriented scheduling system (DOSS). The same report suggests the parallel development of an aircraft and aircrew information system to provide data for the scheduling system (Berman, 1974:91). This two-computer-based-interactive system was designed to manipulate a large volume of data rapidly and allow the scheduler to quickly examine many scheduling alternatives.

Berman stated five basic functions the information should perform:

1. Maintain historical data on aircraft and aircrews.
2. Display measures of performance of the wing as a result of activities performed.
3. Allow detailed projections of the effects of future schedules on performance measures.
4. Answer real-time queries.
5. Prepare reports on a regular basis and perform basic computations [1974:65-66].

The information can stand alone to provide the benefits of more useful and timely data, while also fulfilling the role as a prerequisite for a scheduling system. The DOSS development followed these general guidelines:

1. Provide an interactive man-machine relationship.
2. Use heuristic procedures to develop good schedules which cannot be proved to be mathematically optimal.
3. Adapt to changing environments.
4. Provide graphic capabilities for schedule analysis.
5. Must communicate with the information system in two directions (Berman, 1974:79-82).

The DOSS attempted to cast all SAC wings into a generalized system. What DOSS fails to account for is that each wing is a system in its own right with all the elements generally associated with a system. SAC senior staff chose not to implement DOSS within the command.

A successful attempt to computerize a SAC scheduling function occurred at Whiteman AFB, Missouri for the minuteman combat crew scheduling system. The information data base used by Bush had sequential alphabetical files with personnel data, sequenced file versions with names assigned to crews and organizational units as presented in the monthly operations plan, leave inputs, manual alert input files, and a sequential file containing 66 different codes used in generating reports (Bush, 1978:47). A major drawback noted about this system is the vast storage space required. The Automated Missile Operations Management System uses one main program which accesses numerous subroutines. The subroutines tap the information data base to create a schedule that considers the availability of crew resources. After the final schedule is generated, a feedback loop is executed. Bush uses a statistical compilation program to take data generated in the scheduling process and incorporate this data into the data files (Bush, 1978:64). One final important note about this system is that it uses a mix of interactive and batch methods (see Figure 2.5). The man-machine interactive relationship occurs during input and retrieval. The batch mode takes place to generate schedules and reports. Currently, the Whiteman system operates a smooth allocation of resources (Kerr, 1982).

Egge's work applies a computerized approach to flying training within a tactical fighter squadron. His two major system components are a flight file containing information about each available sortie and a crew member file with data on available individuals capable of manning these sorties. Payoffs result from computations performed on the two data files. The calculated payoff matrix converted to a network

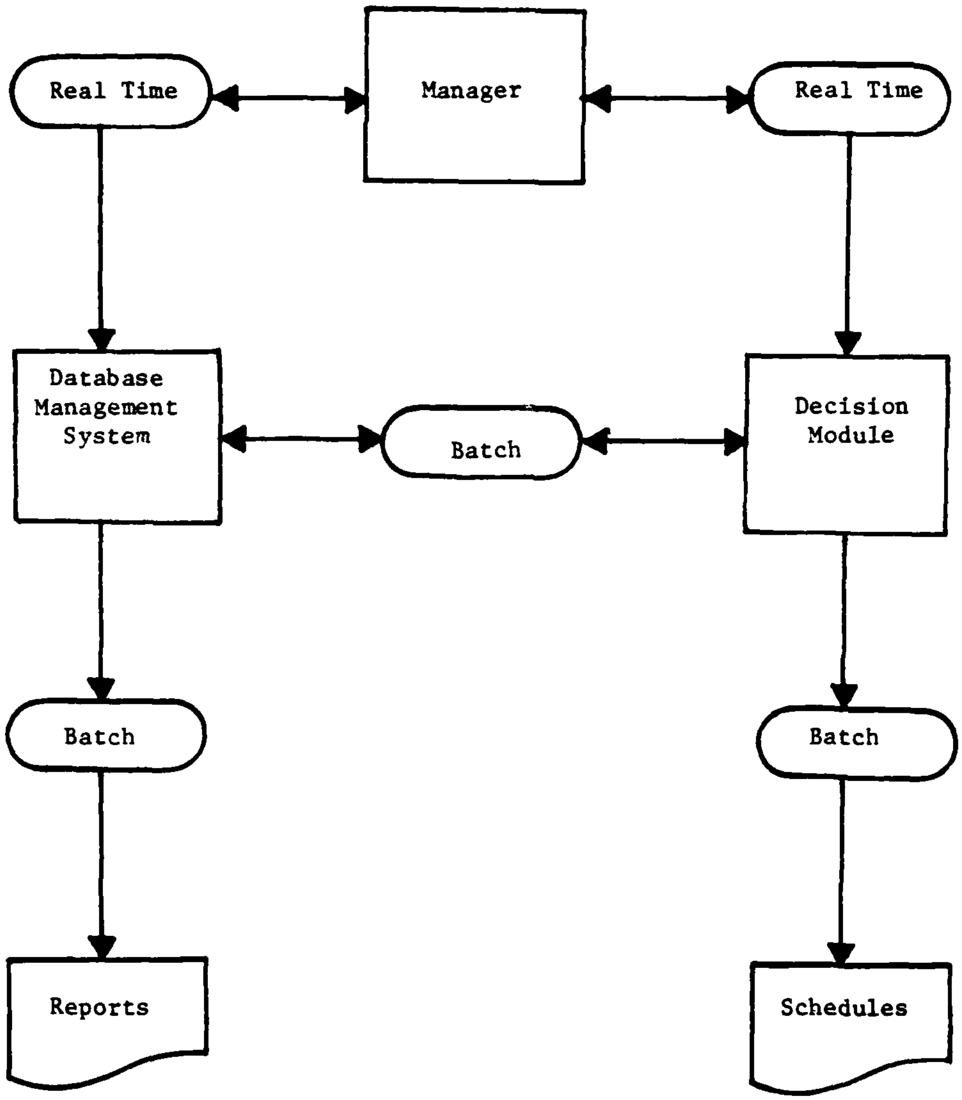

Fig 2.5. Interaction of System Elements
(Bush, 1978:49)

which is solved by a cost-minimizing program gives the man-sortie match providing the greatest payoff. These highest payoff relations are put into the final printed schedule (Egge, 1978:39) (see Figure 2.6). Pease developed an Automated Command Support (ACS.1) system which also involves two principle types of modules.

Figure 2.7 presents a simplified block diagram containing the ACS.1 planner and scheduler modules. The planners generate and monitor the required plans. They handle the complexities of the processes that are intended to meet a given objective. The schedulers coordinate each particular type of resource and handle the complications that may arise from competing demands. Pease noted some features of the system concept relating their prime importance to the scheduling function. First, the division of responsibilities among the planners and schedulers should correspond to the division of responsibility in the comparable human organization. Next, the knowledge contained by the planners and schedulers should be explicit and accessible for modification without major revisions of the system. Finally, the scope and operation of each planner or scheduler should be sufficiently simple to make it readily understandable by the human user (Pease, 1978: 7). An important aspect of the scheduler operation is the data structure termed a "scroll table." This table, in a two-dimensional array, has rows representing a specific resource receiving attention by the scheduler and columns representing some scheduler-oriented time period. Current simulation

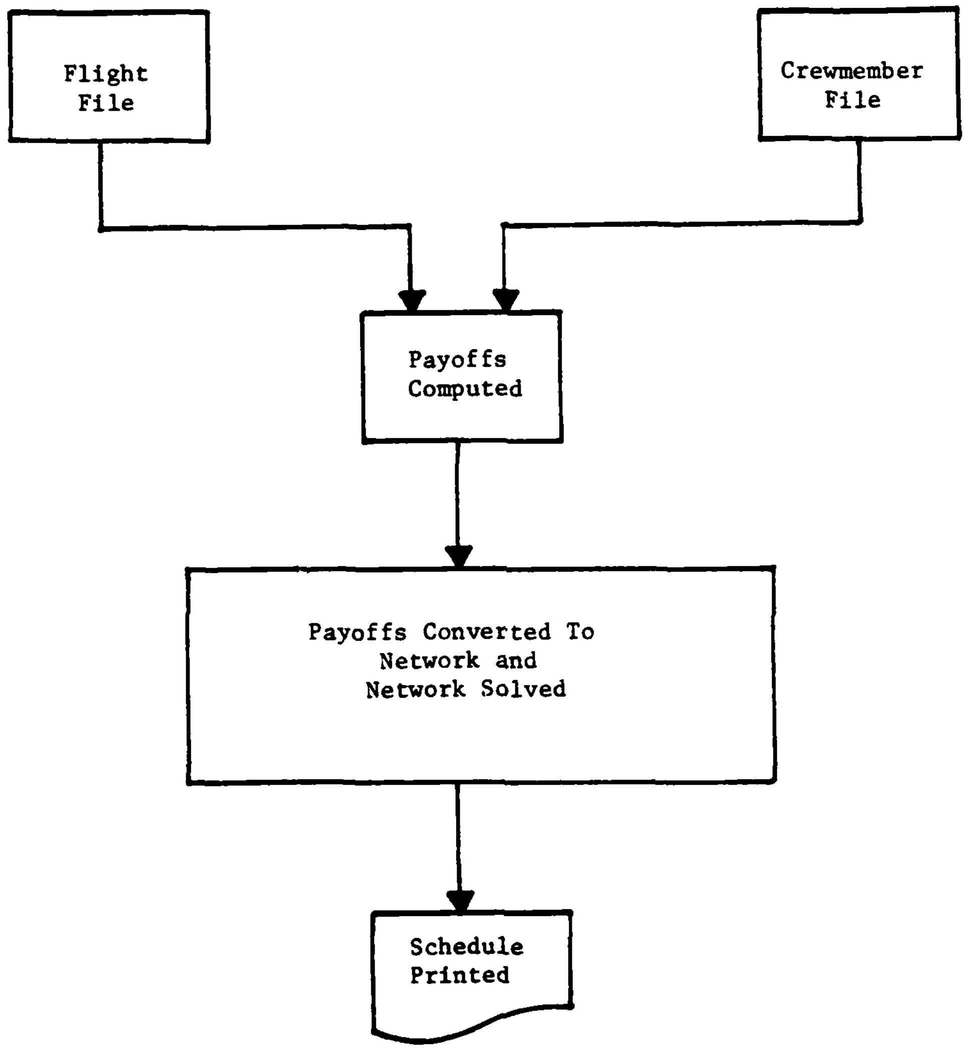

Fig 2.6. Scheduling System Components (Egge, 1978:40)

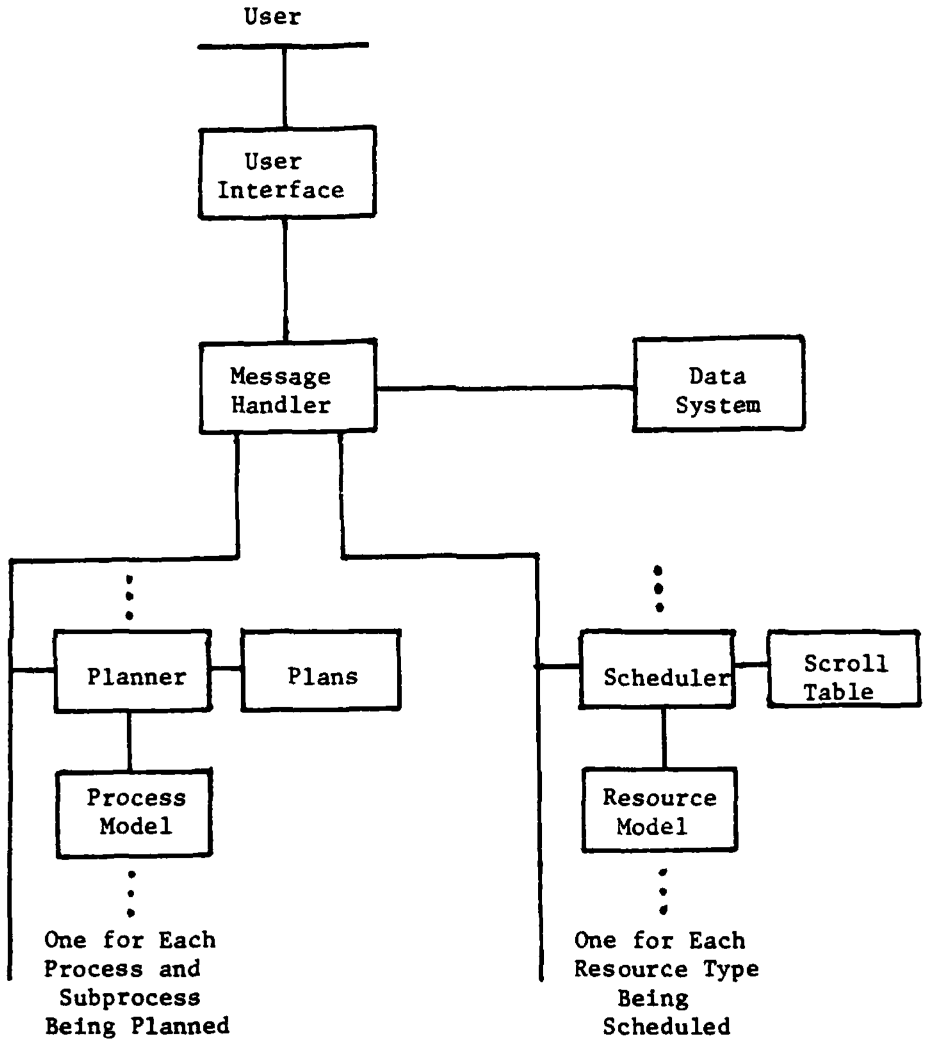

Fig 2.7. Block Diagram of ACS.1
(Pease, 1978:4)

time is maintained in the first column until advancing to the second column. At this time the first column is dropped with the second column now the first. This process scrolls the table as data is held in the applicable row cells of each column. The structure of the scroll table is convenient for planning purposes since when a request is received, the columns for the requested time period can be scanned rapidly to determine the available resources. The knowledge that governs the operation of a scheduler, including what data is entered into the scroll table and its format, is contained in the resource model of the scheduler. Within the models, a complex sequence of actions may be needed to re-establish consistency after a data entry initially creates a violation. The procedural forms that enforce the system's knowledge are called demons (Pease, 1978:22). As used in ACS.1, a demon is a structure containing a condition and a function. It is attached to one or more data elements. If the data element is changed, the condition is tested. If the condition is satisfied, the function is executed with a prescribed list of variables to maintain self-consistency of the data (Pease, 1978: 22). The ACS.1 is a building block system intended to spur the development of techniques for building knowledge-based systems that provide intelligent support to a manager (Pease, 1978:1). A current SAC effort at aiding the decision-maker is the incorporation of microcomputers into the wing scheduling shops as part of the Air Force Operations Resource Management Systems (AFORMS).

The AFORMS is an on-line computer-based system for managing operations resources (flying personnel) of the Air Force. Among other things, it includes modules to manage the training accomplishments of aircrews and individuals. The AFORMS provides strong statistical support to enhance the decision-making processes of unit schedulers, but it does not automatically produce a schedule. Within the deployment time period of 1982, Headquarters SAC personnel expect to build an AFORMS module that will automatically produce a schedule, then interact with the scheduler for more information and revise its decision-making parameters heuristically (Mitchell, 1981). If this occurs, perhaps the SAC scheduling problem will become a moot point. However, in its current state AFORMS does not address the problem of unit differences, and it does not appear the new AFORMS scheduling module corrects this deficiency. Therefore, the identification of decision support systems which aid wing-level decision-makers offer an alternative solution.

Decision Support Systems

The idea of Decision Support Systems (DSS) was first proposed by Michael S. Scott Morton in the early 1970's under the term Management Decision Systems (Sprague, 1980:1). Since then research in the area has continued and several applications of DSS to real-world problem areas have been attempted.

> The role of decision support is to increase the range of a decision-maker's capabilities to make a rational decision. Such a function is accomplished by providing

> a decision-maker with an informational base, as well as organizational, computation, and psychological tools for making a logical decision based on that information. Implicit in this role are two assumptions: (a) decision support is used when human judgment is a critical element, and (b) decision support in no way replaces the decision-maker as a problem solver [Phelps, Halpin, and Johnson, 1981: 1].

The general view of DSS is that it contains three components: a language, a knowledge base, and a problem processing system (Bonczek, Holsapple, and Whinston, 1980:iv).

DSS classification consists of two categories: problem-specific systems, known as "Knowledge-Based Systems" (Pearl, Leal, and Saleh, 1980:1) and generalized support systems, known as "Situation-Based Systems" (Pearl, Leal, and Saleh, 1980:1). According to Pearl, Leal, and Saleh (1980:1), knowledge-based systems use a large data base containing the features and constraints of a given problem environment. It is left up to the user to incorporate this information with other inputs regarding the problem and come up with a decision. Conversely, situation-based systems are independent of the domain. They rely on the user to carry the knowledge and expertise. Only the knowledge the user sees as being relevant to the problem at hand is placed on the computer.

Recent studies (Bonczek, Holsapple, and Whinston, 1979; Wagner, 1981; and Zalud, 1981) have emphasized the need for a DSS to be a generalized support system as opposed to earlier studies (Morton, 1971; Alter, 1977; and Keen and Morton, 1978) where the emphasis was more problem-specific. They point out the need for the support system to be flexible, adaptive, and timely so that it can support not only a single, independent decision, but also several interdependent decisions. In this respect DSS becomes more than just a management information system (MIS) which stores, updates, and retrieves data (Sprague, 1980; and Zalud, 1981). However, the requirement for a good, sound MIS is fundamental in any DSS (Bonczek, Holsapple, and Whinston, 1980; and De and Sen, 1981).

There are six problem characteristics identifiable where a DSS could be applied. These are (Morton, 1971:30-33; Sprague, 1980:4; Wagner, 1981:10; and Keen and Morton, 1978: 96-97):

1. A large data base - DSS is useful where the size of the data base cannot be maintained and searched manually within a reasonable amount of time. This will vary from decision to decision.

2. A continually changing data base - DSS can be very helpful where the data base upon which decisions are made is in a state of flux. This is related to the need to have timely information when making a decision.

3. A need for managers to choose from among alternatives - This relates to the fact that a DSS can assist managers when they must determine the data relevant to the problem, then formulate and evaluate alternative solutions, and finally make a choice from among the possible solutions.

4. Complex interrelationships - DSS can quickly determine the cause and effect relationships between the problem variables and evaluate their impact.

5. A changing environment - The variables and their interrelationships are constantly changing. A DSS can aid the decision-maker in tracking these changes.

6. Some time pressure - This can be either for a final answer or for the decision-making process.

As mentioned earlier, a DSS needs to be flexible, adaptive, and timely. The flexibility requirement implies that the system must be capable of being used by a variety of decision-makers for a variety of purposes (Bonczek, Holsapple, and Whinston, 1980:338-341; Alavi and Henderson, 1981:1310; and Watkins, 1982:38-40). As the need for more information in the problem-solving process is identified, as well as the need to solve other and more varying problems, the DSS should be flexible enough to allow these needs to be incorporated into the system (Bonczek, Holsapple, and Whinston, 1980:338-341; and De and Sen, 1981:29-30).

The second requirement for a DSS is for it to be adaptable. Ralph H. Sprague, Jr. (1980:10-11), in discussing this area, refers to a prior study on adaptive systems by H. Simon. According to Simon an adaptive system must change along three time horizons. First, it must allow a narrow scope search for answers. Second, "the system learns by modifying its capabilities and activities [Sprague, 1980:10]." And third, it must evolve "to accommodate different behavior styles and capabilities [Sprague, 1980:11]."

The third DSS requirement is timeliness. This relates to not only the currency of the data used to make a decision, but also the speed at which the information can be processed and evaluated before making a decision (Bonczek, Holsapple, and Whinston, 1980:340; De and Sen, 1981:29; and Wagner, 1981: 5).

The implementation of a DSS is an iterative module building process (Bonczek, Holsapple, and Whinston, 1980:340; Sprague, 1980:10; and Alavi and Henderson, 1981:1312-1313, 1321-1322). The approach starts with a single problem. The initial DSS is designed to support the decision-making for this one area. After it has been in operation for a short period of time, the system is evaluated, modified, and incrementally expanded. This process is repeated one step at a time resulting in a set of modules which can support a variety of functional and managerial decisions. These modules can be used in an independent or interdependent manner during the decision-making process. This iterative module building approach overcomes three problems of MIS identified by Sprague and Watson (Bonczek, Holsapple, and Whinston, 1980:340). First, MIS models are not easily combined. Second, data must be recollected and reorganized for each run. And third, the model is not easily updated and modified.

DSS uses computers to:

> 1. Assist managers in their decision processes in semistructured tasks.
>
> 2. Support, rather than replace, managerial judgment.
>
> 3. Improve the effectiveness of decision-making rather than its efficiency [Keen and Morton, 1978:1].

The central DSS concept is on improving managerial decision-making effectiveness. The more unstable the environment in which managers operate, the greater the need to focus on increasing their effectiveness. This implies a redefining of the decision-making process.

Applying DSS methodology to any decision-making process requires an understanding of how decisions are made. Keen and Morton have developed a framework of management activity levels and decision types (see Figure 2.8). It can be seen that regardless of the level of management activity, DSS has its best application to semistructured decisions. Semistructured decisions are those which require some balance of human judgment and the use of computers. "Under these conditions the manager plus the system can provide a more effective solution than either alone [Keen and Morton, 1978: 86]."

The design strategy for DSS is illustrated in Figure 2.9. The starting point is the descriptive model which defines the existing decision-making process. At the far end are the normative models which

> are proposals for change: they define the potential range of designs for an information system. . . . For a nonstructured decision, there is no one best solution but rather a range of potential designs [Keen and Morton, 1978:174-175].

The distance between the two models is relative. The larger the distance, the greater are the possible rewards of increasing managerial decision-making effectiveness and the greater are the risks in implementation. The implementation of the normative design often cannot be achieved immediately. This is why the DSS design in Figure 2.9 is shown as a range

Type of Decision/Task	MANAGEMENT ACTIVITY			
	Operational Control	Management Control	Strategic Planning	Support Needed
Structured	Inventory Reordering	Linear Programming for Manufacturing	Plant Location	Clerical, EDP or MS models
Semistructured	Bond Trading	Setting Market Budgets for Consumer Products	Capital Acquisition Analysis	DSS
Unstructured	Selecting a cover for *Time* magazine	Hiring Managers	R&D Portfolio Development	Human Intuition

Fig 2.8. A Framework for Information Systems [Keen and Morton, 1978:87]

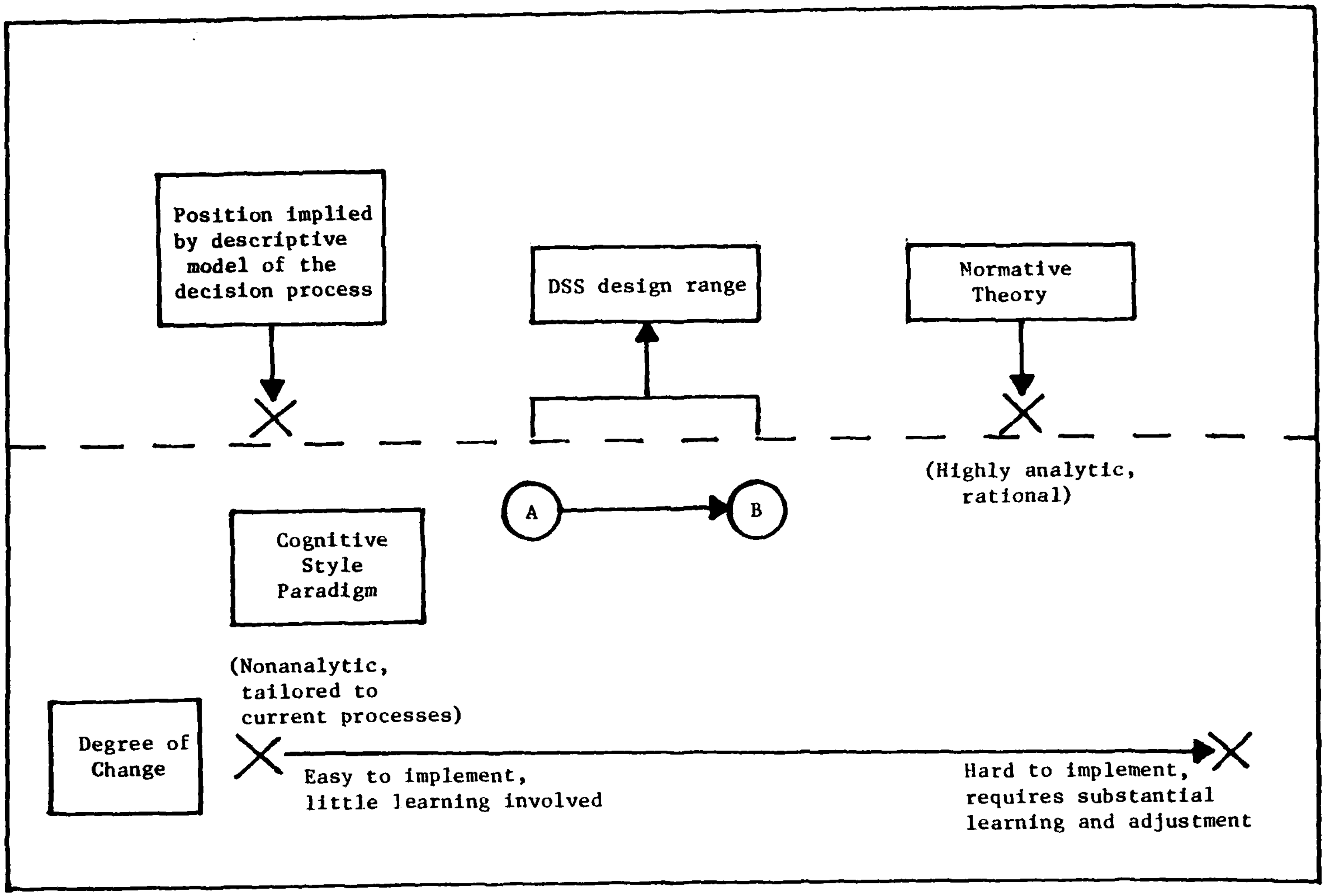

Fig 2.9. Designs Based on Cognitive Theory Perspective (Keen and Morton, 1978:175)

between extremes on a continuum. The DSS methodology implies an iterative implementation: "What is needed is a design that begins from a position close enough to the descriptive model for implementation to be practicable and permit further evolution [Keen and Morton, 1978:176]."

Preceding the implementation of the DSS, point A in Figure 2.9 is the cognitive style paradigm. This refers to the personality and decision-making style of a manager or group of managers. The idea behind this paradigm is that the DSS designer must take into consideration the user's view of what is important in the decision-making process. Care must be taken in determining the cognitive style of the system's users to assure the DSS increases decision-making effectiveness by making it compatible with the needs of the managers.

> The cognitive style paradigm emphasizes the problem-solving process rather than cognitive structure and capacity. It categorizes individual habits and strategies at a fairly broad level and essentially views problem-solving behavior as a personality variable [Keen and Morton, 1978:74].

The environment in which managers function differs from most other environments in two ways (Pease and Sagalowicz, 1979). First, problems encountered by managers are not routine and predictable. Therefore, it is necessary to adjust the DSS to the actual needs as the problem evolves. Second, managers are the experts. They must understand how the system behaves and the reasons for the actions it takes. These requirements indicate managers must be able to modify a system even though they have little knowledge of programming and system design.

The key design issue is to provide a way for the user to exercise control without requiring a knowledge of system implementation.

The implication of DSS is that the normative model does not exist, but one can be designed; however, it cannot be implemented immediately. When comparing the descriptive and normative models, a range of choices exists among design alternatives. This range implies that moving from implementation at point A in Figure 2.9 to a point further down the continuum, say point B, is possible before a re-evaluation of the system is required. At this time the system is analyzed to determine if the normative model has changed. The new descriptive model now lies somewhere between points A and B, and the design strategy continues.

After the implementation process has begun, the system's designer and user interact to determine how the system will evolve. Since it is difficult to know all the needs of the user, the initial DSS serves as a test model providing the user with hands-on experience. Through his experience, the user becomes adept at providing impetus to the system's evolution by suggesting improvements and additions.

> This means that the first stage in the long-term process of evolution should be . . . to design and deliver a system that is seen as usable and useful <u>now</u>; but the interface software should be flexible enough to allow rapid extension and addition of routines. The second phase, which would probably begin after 3 months to 1 year of experience with the original system, will involve design of a few powerful routines that extend the decision-maker's efforts and abilities [Keen and Morton, 1978:185].

This concept leads to a re-evaluation of the design strategy, a new descriptive model, and perhaps a revised normative model. Therefore, the "old" system becomes the input for the "new" system at the next design stage which requires a revised model, data base, and processing network.

The successful completion of a DSS aiming at improved decision-making depends on:

1. A prior definition of 'improvement.'
2. A means of monitoring progress toward the predefined goal.
3. A formal review process to determine when the system is complete [Keen and Morton, 1978:213].

Current applications of DSS are wide and varying. It is used in financial and economic analysis, annual planning, strategic planning (Wagner, 1981:12; Bonczek, Holsapple, and Whinston, 1979:284; and Bonczek, Holsapple, and Whinston, 1980: 341-345), the military, public policy making, land management, oil exploration (Phelps, Halpin, and Johnson, 1981:1), and the scheduling of resources to meet demands for those resources (Balachandran and Zoltners, 1981:809-810).

Once a suitable model has been formulated and verified, data to support the computerized DSS needs to be acquired or assembled.

Data Bases and Data Base Management

Data comes from both external and internal sources (Sprague, 1980:14; and De and Sen, 1981:30-33). A sound data for decision support must incorporate all relevant bits of data (Sprague, 1980:14; and Clemons, 1980:22). Data base management is the "process of creating and updating a data base by defining data for the user's needs and by determining how these data are interrelated [De and Sen, 1981:31]." The design and management of the data base is a critical part of any DSS (Sprague, 1980:20-21; and De and Sen, 1981:30).

De and Sen identify four considerations for data base design which enables it to achieve its goal of producing a data base that satisfies organizational requirements (1981: 30). First, the needed information must be available. Second, data processing time constraints must be met. Third, data representation must be simple and easily comprehensible so that it can be used by anyone within the organization. And finally, it should be flexible enough to allow for future needs.

The development of a data base should stress user involvement from the beginning. This is an essential concept in the cognitive style paradigm; only the user can really be aware of the data needed for transformation into information to aid in the decision-making process (Pease, 1974:3). It should also be stressed that data base design is an iterative process; as the system develops, additional information needs to be added, while some previously incorporated data can become redundant, obsolete, or superfluous (Clemons, 1980:23).

Information is required for decision-making. This is true whether quantitative or qualitative information is used, and whether the decision is subjective, highly structured, or somewhere in between (Keen and Morton, 1978:86-87; and Clemons, 1980:2). An objective of a DSS is to provide a data-based system that can effectively assist in the decision-making process (Pease, 1974:1). Therefore, data base design is an important component of any DSS.

McElmoyle identifies ten attributes of the information used in data bases for a DSS (1980:29-30):

1. Accessibility - the ease and speed with which information output is obtained.

2. Comprehensiveness - the completion of information content.

3. Accuracy - the degree to which information output is free of error.

4. Appropriateness - this refers to how well the information output relates to the user's request.

5. Timeliness - the user must receive the information within the time allowed for the decision to which it applies.

6. Clarity - the degree to which information output is free of ambiguity.

7. Flexibility - the adaptability of information output to more than one decision and more than one decision-maker.

8. Verifiability - the ability of several users examining a bit of information output to arrive at the same conclusion.

9. Freedom from Bias - the inability of the information to produce a preconceived conclusion.

10. Quantifiable - this refers to the nature of the information output.

In building the data base for a DSS, Clemons devised five guidelines for data base design (1980:4-6). First, exploit the knowledge of traditional, file-based inquiry systems. This permits rapid access to file subsets. Second, design for the specific nature of DSS. Here the data base should be designed for the verbs supported by the DSS. Third, keep auxiliary data for use in the DSS. This is for data requiring extensive access. This way the entire data base does not need to be scanned each time access to a particular bit of data is required. Fourth, note when auxiliary data becomes obsolete. This avoids using outdated data. And fifth, recalculate auxiliary data rapidly. The emphasis here is on rapidly updating the data base.

Once the data base has been designed, there are five objectives which the information processing system must meet (Sibley and Merten, 1972:3-6). The first objective is data independence. The way the data is stored must be independent from the way the programs using the data are written. Next, the data must not be redundant. Here the system is restrained from having more than one value for a data item. Third, data relationships must be defined by the user. Data integrity and security is the fourth objective. Data integrity is the capability to retain data under conditions of system failure. And data security is the ability to allow only authorized individuals access to the data. Finally, the data must be reliable. The problem of maintaining the data's accuracy can be accomplished by simple validation rules.

A key person in the design of data-base systems is the data base administrator. He is responsible for data definition (the description of the data structure), updating the data base (changes or additions to the data), interrogation of the data base (the programming language and the user interface language), and the integrity and security of the data base (Sibley and Merten, 1972:7-9).

Summary

This chapter discussed the scheduling system and approaches to the scheduling problem. Next, the concepts of decision support systems, the requirements of the supporting DSS data base, and the techniques of data base management were presented. Chapter 3 ties these subjects together and describes the methodology that is used in Chapters 4 and 5 to build the functional and informational models, respectively.

Chapter 3

RESEARCH METHODOLOGY

DSS and Aircrew Scheduling

Schoderbek, Schoderbek, and Kefalas (1980:195-196) suggest a decision-making process consists of four phases. First, recognize the need for a decision to be made. Second, determine possible courses of action. Third, select an alternative course of action. And fourth, implement and evaluate the chosen alternative or decision. Implicit in the decision-making process is the need for information.

A problem in the decision-making process involves the acquisition and evaluation of data to obtain relevant information for the decision, and then proposing alternative courses of action. Given the availability of data, what generally occurs is the existence of a large amount of data which must be manipulated into some usable form in a short period of time. This usually requires decision-makers to use their judgment to recognize the problem, determine courses of action, or make a decision. Because of the time pressure, the data, and the need to manipulate the data, decision-makers often define problems, create alternatives, or make decisions without all the needed information.

Keen and Morton (1978:96-97) suggest this type of situation lends itself to the application of a Decision Support

System (DSS). As mentioned earlier, a DSS is a methodology that assists managers in the decision-making process, supports managerial judgment, and improves decision-making effectiveness, not efficiency (Keen and Morton, 1978:1). The more unstable the environment, the greater is the need to focus on increasing managerial effectiveness.

A DSS is based on a "balance between human judgment and computer replacement [Keen and Morton, 1978:11]." Because of this, Keen and Morton state that regardless of the level of management activity, the most beneficial application of DSS lies where the type of decision is semistructured (1978: 81-88).

It has been shown that SAC B-52 aircrew scheduling is a decision-making process which requires a vast amount of data needing manipulation, and it operates under various time constraints. Also according to Zalud, scheduling consists of semistructured activities which cannot be entirely automated because the decision-making process involves managerial judgment (1981:21). Therefore, the design of a DSS for SAC B-52 aircrew scheduling is appropriate. A DSS for this scheduling process should consist of

> . . . three components (an optimization model, an interactive scheduling capability, and a data base); the system is designed to enable the scheduling manager to develop objective and implementable schedules [Balachandran and Zoltners, 1981:812].

It is essential in building a DSS that first the decision-making process be modeled to obtain a detailed understanding of management decision processes (Keen and Morton, 1978:81).

Modeling Approach

The purpose of this research is to construct a model of the necessary operations in the overall aircrew scheduling process for a SAC B-52 wing and then develop the informational model for one of the lower level planning decisions. Specifically, the monthly assignment of individuals by name to ground alert duty is modeled. Because each SAC wing is itself a unique system, this research focuses on the aircrew scheduling process for the two B-52 bombardment squadrons of the 28th Bombardment Wing at Ellsworth AFB, South Dakota. In order to construct these models for this bomb wing, it is necessary to select a modeling technique in which exists the capability to develop a functional model and an informational model.

The Materials Laboratory of the Air Force Wright Aeronautical Laboratories, with the assistance of SofTech Incorporated, developed a promising modeling approach based on SofTech's Structured Analysis and Design Technique. It was designed for the United States Air Force's Integrated Computer-Aided Manufacturing (ICAM) program. ICAM "is directed toward increasing manufacturing productivity through the systematic application of computer technology [Ross et al., 1981:3]." The program developed three graphical modeling methods known as ICAM Definitions (IDEF). This modeling approach is a systems design architecture which provides a blueprint defining "the fundamental relationships--the functional interfaces, identification of common, shared and discrete information, and dynamic interaction of resources [Ross et al., 1981:

3-4]." Onl' the first two modeling techniques are addressed in this research.

$IDEF_0$ Concepts, Diagrams, and Procedures

> $IDEF_0$ is used to produce a function model which is a structured representation of the functions of a manufacturing system or environment, and of the information and objects which interrelate those functions [Ross et al., 1981:3].

However, this methodology can be used to model any system composed of hardware, software, and people (Ross et al., 1981: 10). The final model is a set of box and arrow diagrams with supporting documentation (i.e., text and glossary) that breaks the system into its component parts and underlying functional relationships.

On each diagram the major component at that structural level is shown as a box.

> Each detailed diagram is the decomposition of a box on a more general diagram. At each step, the general diagram is said to be the "parent" of the detailed diagram. A detailed diagram is best thought of as fitting "inside" a parent box [Ross et al., 1981:19]. [See Figure 3.1]

Each box represents an active functional process which occurs over time and transforms input into output.

Boxes are connected by arrows which represent data that is transformed by the function. The arrows provide definition for the boxes; they are "not sequences or flows of functions [Ross et al., 1981:22]." The arrows affect the boxes in different ways. An arrow's effect can be determined by noting the side of the box where it enters or leaves (see Figure 3.2). An input arrow represents data that is

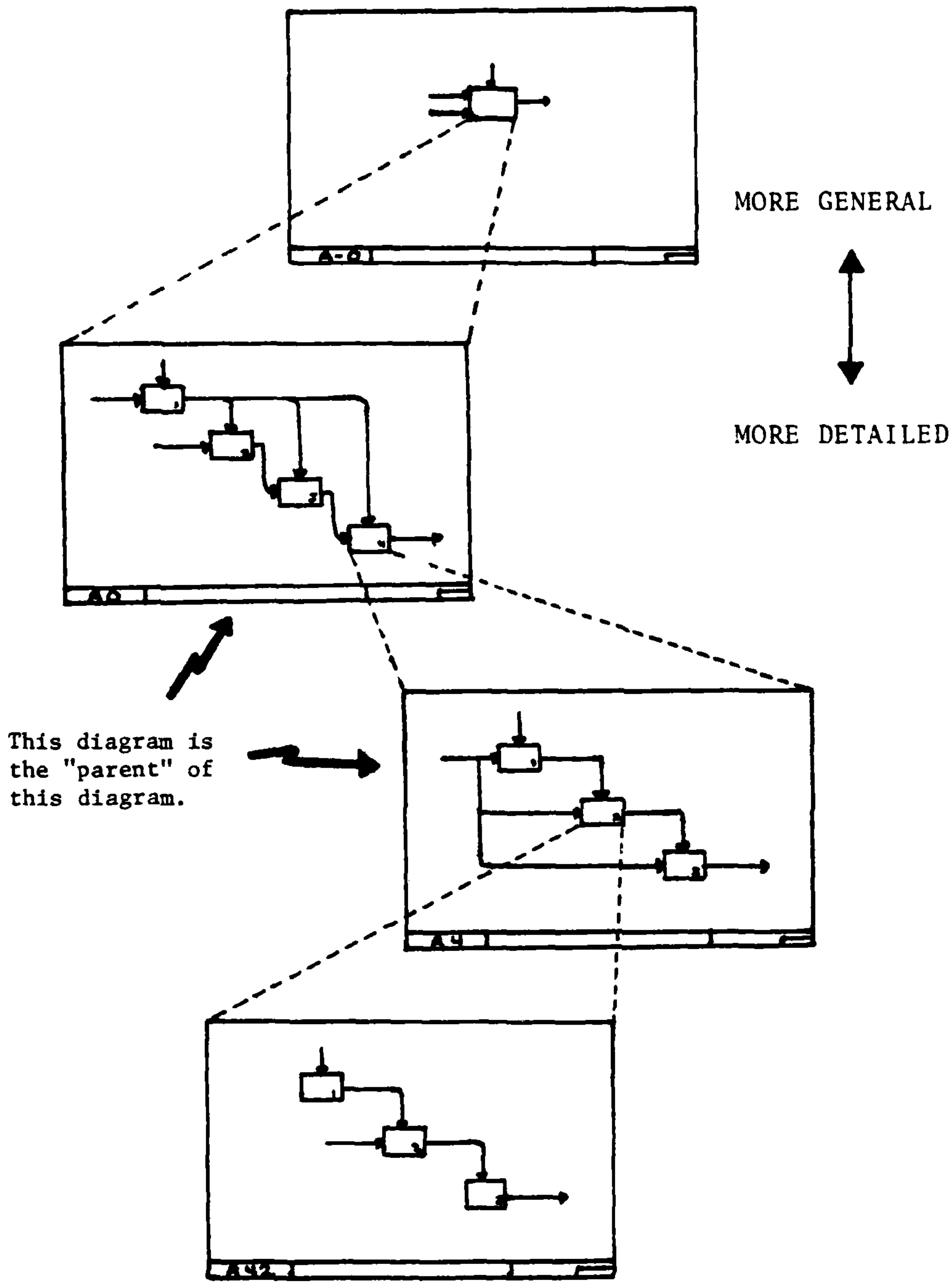

Fig 3.1. Decomposition of Diagrams
[Ross et al., 1981:20]

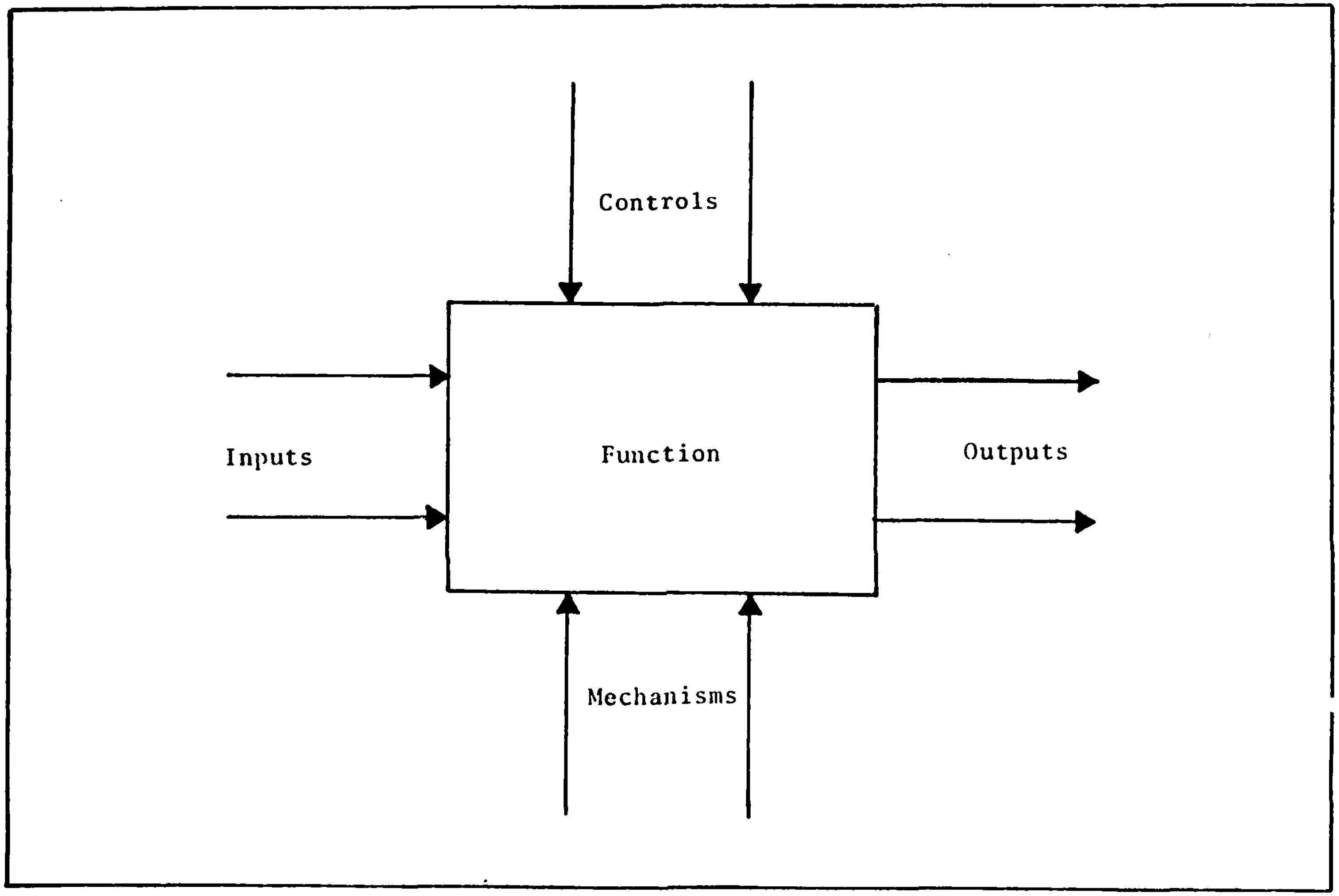

Fig 3.2. $IDEF_0$ Function Box and Interface Arrows (Ross et al., 1981:11)

transformed by the function specified in the box. An output is data which either results from or is created by the functional box. A control differs from an input in that it determines the function or tells why the transformation is taking place. Finally, a mechanism defines how a function is performed. Arrows are labeled to identify what they represent. If an arrow branches, each branch is also labeled.

> On any given diagram, data may be represented by an internal arrow (both ends connected to boxes shown on the diagram) or a boundary arrow (one end unconnected, implying production by or use by a function outside the scope of the diagram) [Ross et al., 1981: 26].

A boundary arrow's source or destination is found by referring to the parent diagram. It is important to realize that the function inside the box cannot be performed until all required data shown by the incoming arrows have been provided.

Each $IDEF_0$ diagram is supported by written text and a glossary to aid in defining the system. They are intended to emphasize significance or clarify the intent of the diagram, not duplicate its detail. Additionally, a node index is provided for convenience in accessing any desired level of detail.

One important feature (Ross et al., 1981:12-14) of the $IDEF_0$ modeling technique is that it slowly introduces more and more levels of detail as each function is decomposed into its subfunctions. The procedure starts by representing the modeled system as a single box with arrow interfaces to functions outside the system. At this level both the descriptive name of the box and its arrows are general. This general function is then broken down into its major subfunctions with their arrow interfaces. Each subfunction can be further decomposed in order to reveal even more detail. Every subfunction can contain only those elements lying within the parent model's scope, and it cannot omit any elements of the parent model. The decomposition of the system stops when the desired level of detail has been reached (see Figure 3.1).

The diagrams are finally arranged in a hierarchical format by breaking down each functional box into its more detailed functions. Such a hierarchical structure, known as a node tree, is shown in Figure 3.3.

> All node numbers of $IDEF_0$ diagrams begin with the letter A, which identifies them as "Activity" or function diagrams. A one-box diagram is provided as the "context" or parent of the whole model. By convention, the diagram has the node number 'A-0' (A minus zero) [Ross et al., 1981:33].

The arrows associated with this diagram are called external arrows because they represent the system's environment, while the box establishes the context of the modeled system.

Boundary arrows for all lower level diagrams must be labeled with an ICOM code.

> The letter I, C, O, or M is written near the unconnected end of each boundary arrow on the detail diagram. This identifies that the arrow is shown as an Input, Control, Output, or Mechanism on the parent box. This letter is followed by a number giving the position at which the arrow is shown entering or leaving the parent box, numbering left to right and top to bottom [Ross et al., 1981:37]. [See Figure 3.4]

Arrows shown as inputs or controls on a parent diagram are not limited to the same role throughout the decomposition (Ross et al., 1981:37).

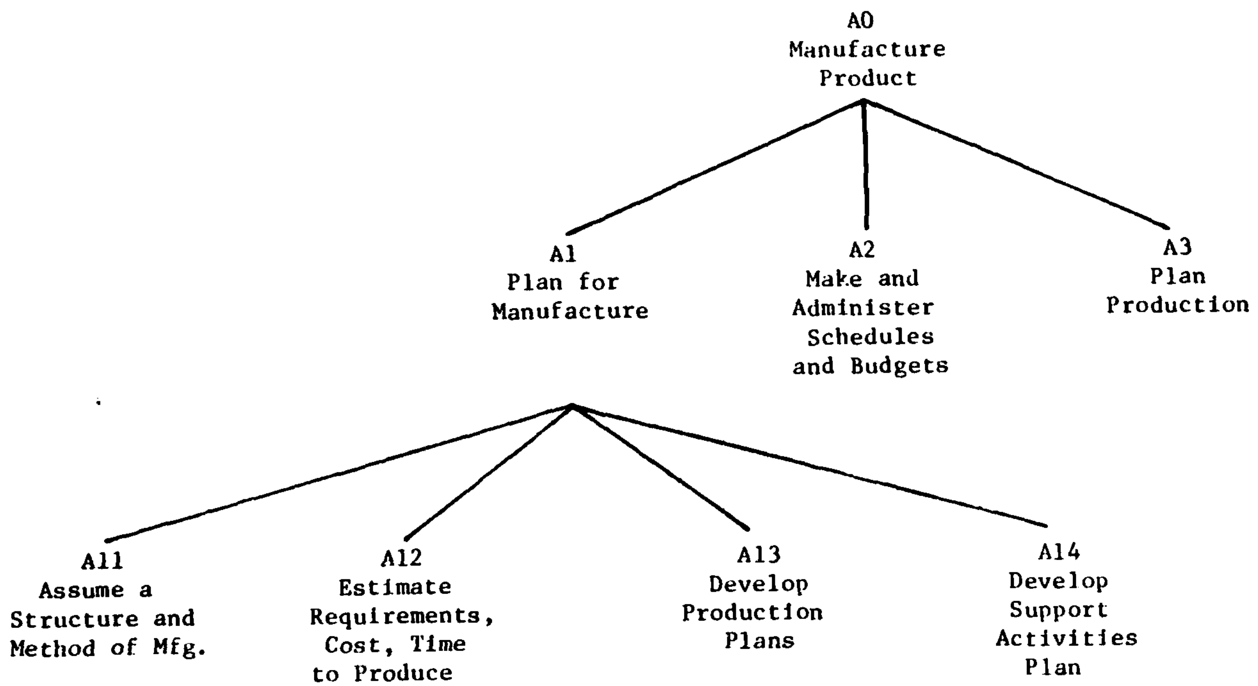

Fig 3.3. Diagrams Form a "Hierarchy" Shown by a Node Tree
[Ross et al., 1981:33]

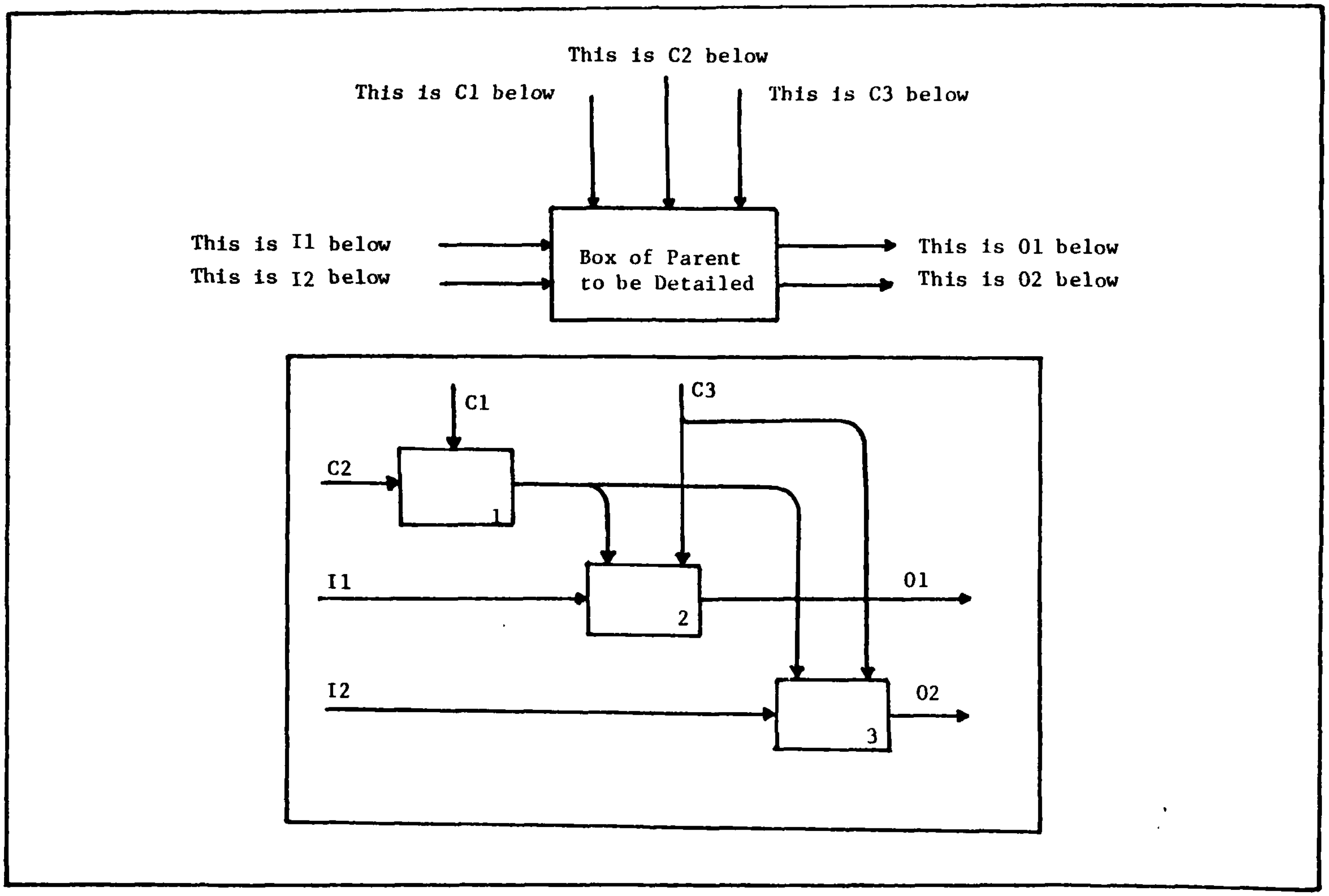

Fig 3.4. Codes are Written on the Detail Diagram
[Ross et al., 1981:38]

Once the functional model has been built for the system, the next step is to take the functional model and develop its informational model. This is accomplished by using ICAM $IDEF_1$ methodology and constructing the informational model for each functional process. The approach is similar to the DSS idea of building decision support modules.

$IDEF_1$ Concepts, Diagrams, and Procedures

"$IDEF_1$ is used to produce an information model which represents the structure of information needed to support the functions of a manufacturing system or environment [Jones, et al., 1981:3]." Like $IDEF_0$, $IDEF_1$ can be used to model any system. Using an Entity-Relation-Attribute (ERA) approach, *the final model* is a set of two types of box and line diagrams with supporting documentation (i.e., ERA dictionary and glossary).

One type of diagram, known as an Entity Diagram, represents the relationship between real or conceptual things (see Figure 3.5). The other type of diagram represents the relationship between a property or characteristic of an entity, and is known as an Attribute Diagram (see Figure 3.6). The boxes specify the entity or attribute and the lines represent the relationships between the entities and attributes (Jones et al., 1981:26 and 31).

When constructing the informational model for a system, the author must keep three key concepts in mind. First, what is the purpose of the model (Jones et al., 1981:51)? This

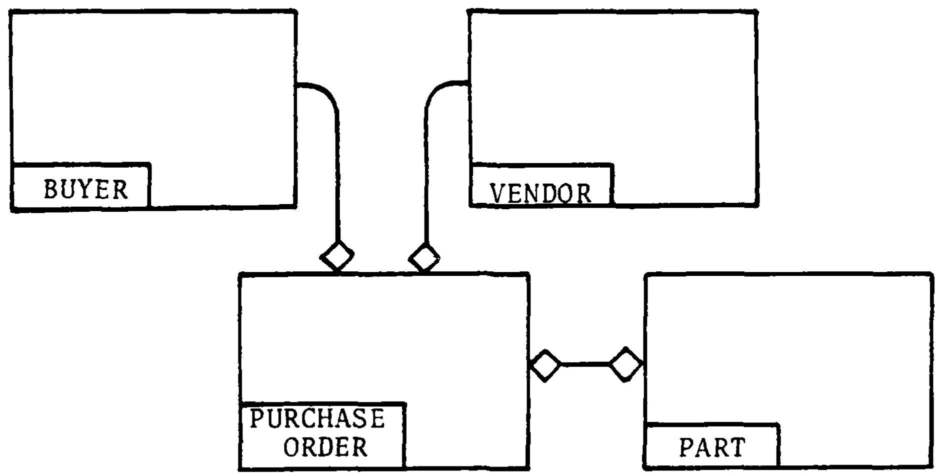

Fig 3.5. Entity Diagram of an ICAM Information Model: Purchase Order Example [Jones et al., 1981:28]

answers why the model is being developed and what use will be made of it (Jones et al., 1981:71-72). Second, the model's viewpoint must be kept in mind (Jones et al., 1981:51). This allows for identifying sources of information (Jones et al., 1981:71-73). And finally, work with classes of entities, attributes, and relationships--not individual ones (Jones et al., 1981:21, 25, and 29). With these three concepts in mind, the author of the model will be able to establish a set of viable criteria for the model and remain consistent throughout the model's development (Jones et al., 1981:8 and 51).

The diagrams of an informational model help to "tell a story" about the model (Jones et al., 1981:8). As the model evolves more is learned about the system and its relationships, and new aspects may be discovered. The modeling procedure insures the Entity Diagram supports the Attribute Diagram and

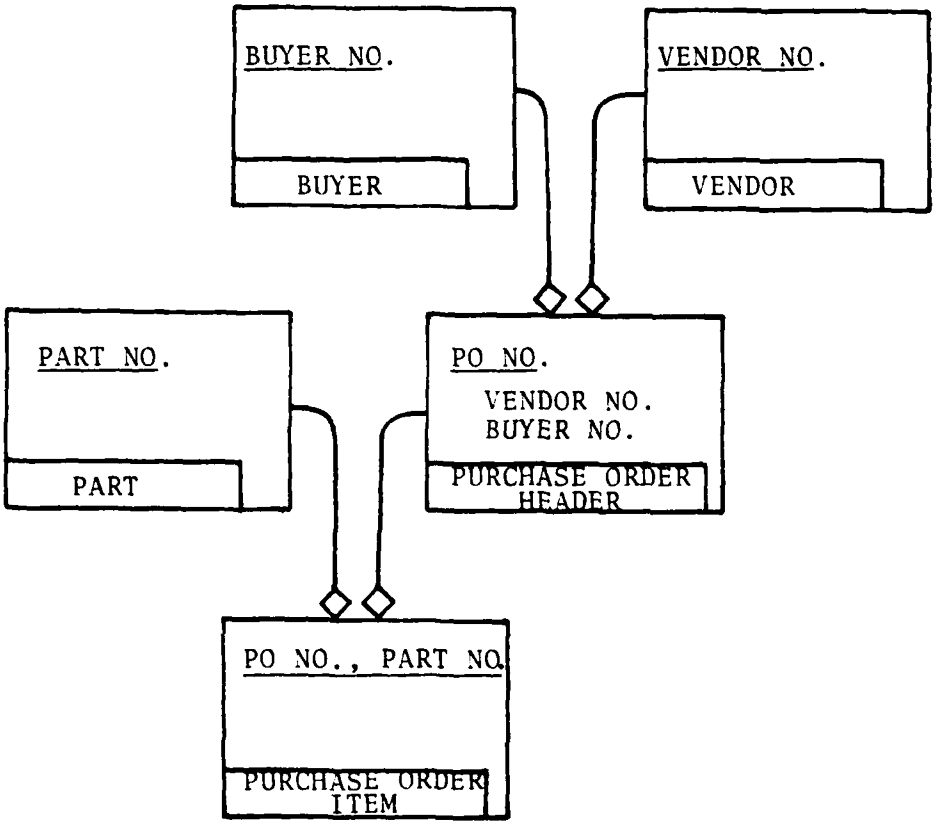

Fig 3.6. Attribute Diagram of an ICAM Information Model: Purchase Order Example [Jones et al., 1981:33]

vice versa. The two together help form the informational model (Jones et al., 1981:8).

Entity Diagrams, the more general of the two, have four characteristics associated with them (Jones et al., 1981:42-45 and 48):

1. Entity and relation classes are shown;
2. No attribute classes appear;
3. The four types of relation classes may be shown; and
4. Relation classes are labeled.

Attribute Diagrams, the more detailed of the two types of diagrams, have six characteristics associated with them (Jones et al., 1981:46-48):

1. Entity and relation classes are shown;
2. All entity boxes contain key classes;
3. No "many-to-many" relation type classes are allowed;
4. For "one-to-many" relationships, the entity class at the "many" end contains a key class from the "one" end;
5. For "one-to-one" relationships, a key class from both entity classes appear at each end; and
6. Relation classes are labeled.

As mentioned above there are four types of relation classes which can appear in the diagrams. They are (Jones et al., 1981:41):

1. One-to-one;
2. One-to-many;
3. Many-to-one; and
4. Many-to-many.

An example of an Entity Diagram and Attribute Diagram with their relationships is depicted in Figure 3.7.

In conjunction with the diagrams, an ERA Dictionary is written to complete the informational model. The dictionary is a glossary which captures the meanings people attach to the entity, relation and attribute classes depicted in the model (Jones et al., 1981:8). It contains an entry, a list of synonyms, and description for each entity and attribute

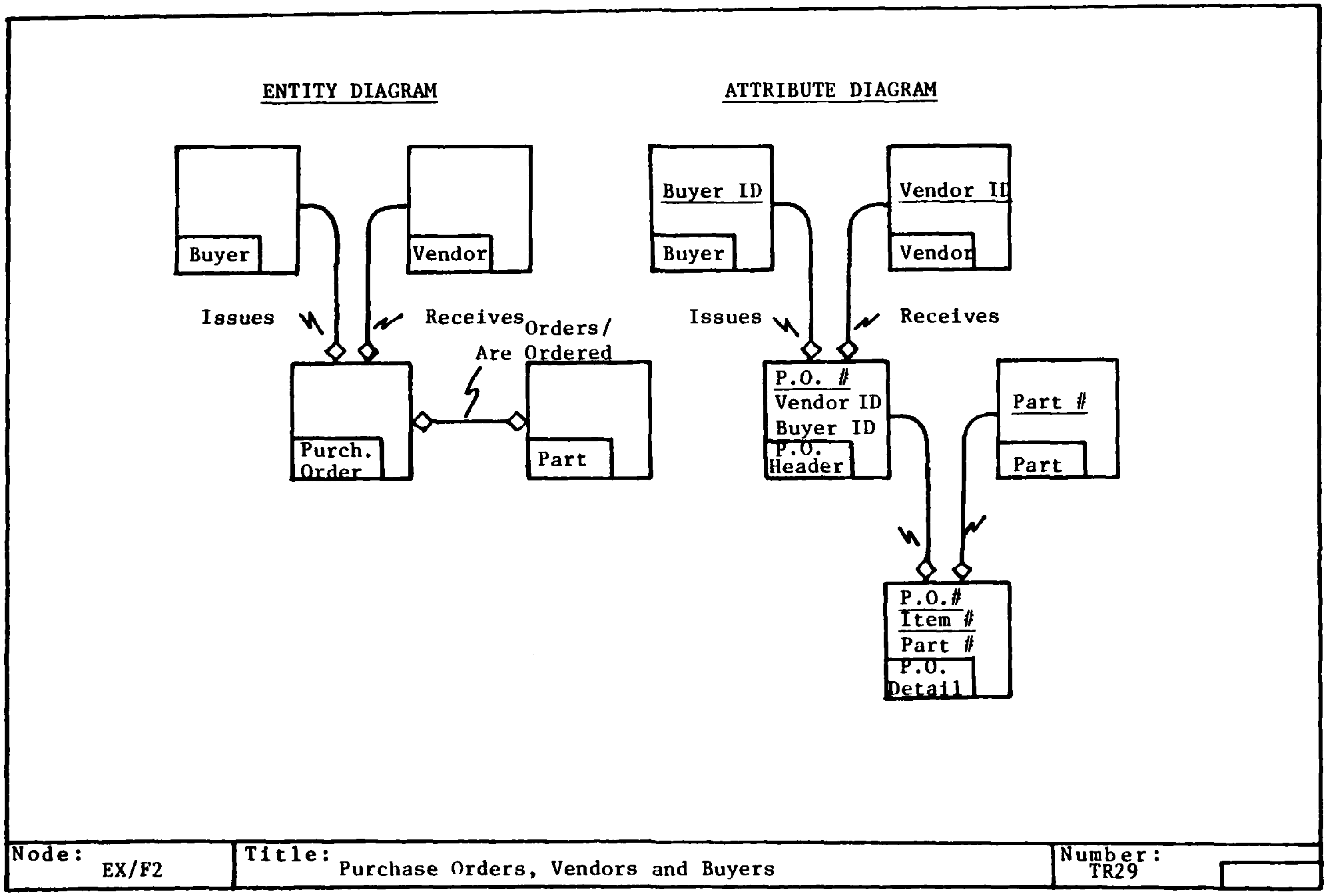

Fig 3.7. Entity Diagram and Attribute Diagram
(Jones et al., 1981:28 and 33)

class (Jones et al., 1981:21 and 31). And finally, all attribute classes for each entity class are listed (Jones et al., 1981:29 and 31).

Summary

This chapter has presented an argument for applying DSS concepts to a SAC B-52 wing aircrew scheduling process. It defined the $IDEF_0$ methodology which is used to construct a functional model, presented in Chapter 4, for this process. And it described the $IDEF_1$ methodology that is used in Chapter 5 to build an informational model for the monthly assignment of individuals by name to ground alert duty. Because each wing is a unique system, Chapters 4 and 5 focus on the SAC B-52 aircrew scheduling process for the two bombardment squadrons of the 28th Bombardment Wing at Ellsworth AFB, South Dakota. A parallel thesis develops a functional model for this wing's aircraft maintenance scheduling process (Hackett and Pennartz, 1982).

Chapter 4

$IDEF_0$ FUNCTION MODEL

Introduction

A B-52 organization attempts to accomplish established unit mission objectives. Various activity plans provide the framework for allocating resources to requirements toward unit goal accomplishment. Plan implementation followed by results evaluation complete the organizational cycle depicted in Figure 4.1. The four elements each represent an A-0 level within the $IDEF_0$ model methodology. Only the "plan" element appears as a functional model with this thesis. The internal chapter organization includes node tree diagrams and indexes indicating major planning functions within units operating B-52 weapon systems. The detailed functional model comprises the bulk of the chapter content. The model focuses upon collections of related functions in an effort to enhance reader understanding by eliminating unnecessary details. Chapter 5 does present one detailed information element example which when compared with the functional model provides the reader an insight into the job complexity of a unit B-52 planner.

Node Index and Trees

The model overview occurs within the node index/trees within this section. "'Node index' order means that all

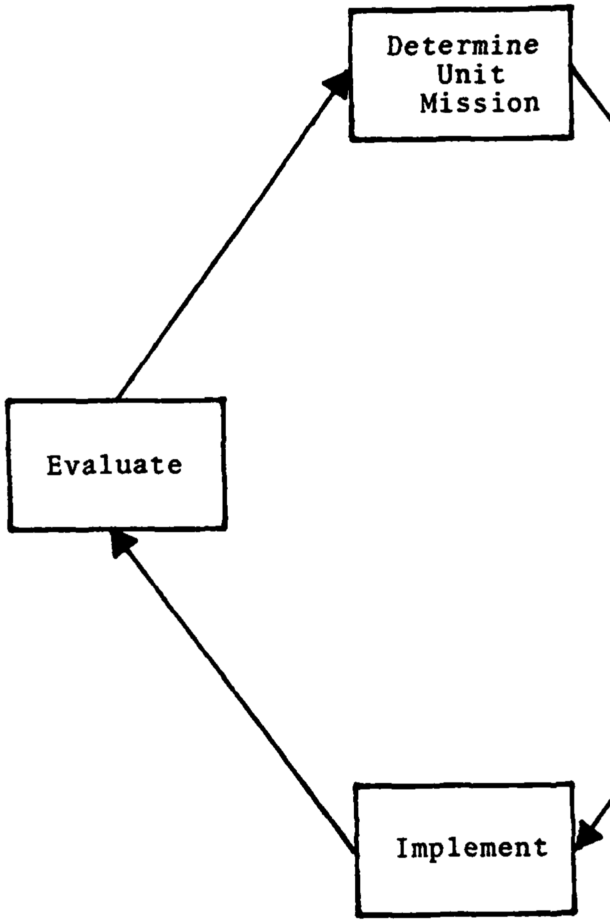

Fig 4.1. $IDEF_0$ A-0 Levels of Accomplish Unit B-52 Activity

detail diagrams relating to one box on a diagram are presented before the details of the next box [Ross et al., 1981:50]." The node index, Figure 4.2, provides a quick reference to a specific location by placing related diagrams together in the same order as in an ordinary table of contents. The node trees, Figures 4.3 to 4.6, give a diagrammatic perspective of the hierarchical relationships between the nodes. The reader is encouraged to use the index to locate specific diagrams presented in the functional model.

- A0 Plan Unit B-52 Activities
  - A1 Plan Operational Activities
    - A11 Determine Operational Planning Needs
      - A111 Review Applicable Directives
        - A1111 Review Air Force and Related Publications
        - A1112 Review Major Air Command Directives
        - A1113 Review Local Procedures
      - A112 Research Unit Commitment Possibilities
        - A1121 Coordinate with Higher Headquarters Contacts
        - A1122 Coordinate with Wing Staff
        - A1123 Coordinate with Squadron Personnel
      - A113 Review Available Unit Historical Records
        - A1131 Review Unit Accomplishments
        - A1132 Review Previous Unit Schedules
        - A1133 Review Unit Evaluation Reports
        - A1134 Review Previous Unit Planner's Methodology
    - A12 Compile Operational Planning Data
      - A121 Collect Requirements Data
        - A1211 Collect Unit Mission Requirements Data
        - A1212 Collect Higher Headquarters Requirements Data
        - A1213 Collect Unit Training Requirements Data
      - A122 Collect Resource Data
        - A1221 Collect Aircrew Member Status Projections
        - A1222 Collect Aircraft Availability Data
        - A1223 Collect Support Capability Data
      - A123 Construct Planning Aids
        - A1231 Build Feasible Sortie Profiles
        - A1232 Build Tentative Weekly Flow Charts
        - A1233 Build a Master Programming Calendar
    - A13 Develop Operational Scheduling Plans
      - A131 Prepare Quarterly Plan
        - A1311 Analyze Available Data
        - A1312 Fill Unit Mission Requirements
        - A1313 Fill Higher Headquarters Requirements
        - A1314 Fill Unit Training Requirements
        - A1315 Attend Quarterly Planning Conference
      - A132 Refine Monthly Operations Plan
        - A1321 Revise Quarterly Planning Factors
        - A1322 Construct Monthly Schedules
        - A1323 Resolve Standardization Schedule
        - A1324 Integrate Wing-Directed Training
        - A1325 Incorporate Recurring Academic Training
      - A133 Construct Weekly Operations Schedules
        - A1331 Analyze Current Status vs Planned
        - A1332 Assign Individuals by Name to Ground Alert
        - A1333 Tailor Specific Training Sorties Duty
        - A1334 Coordinate Weekly Schedule
      - A134 Adjust Daily Schedule
        - A1341 Obtain Situation Changes
        - A1342 Determine Mission Alternatives
        - A1343 Coordinate Schedule Deviations

Fig 4.2. Node Index

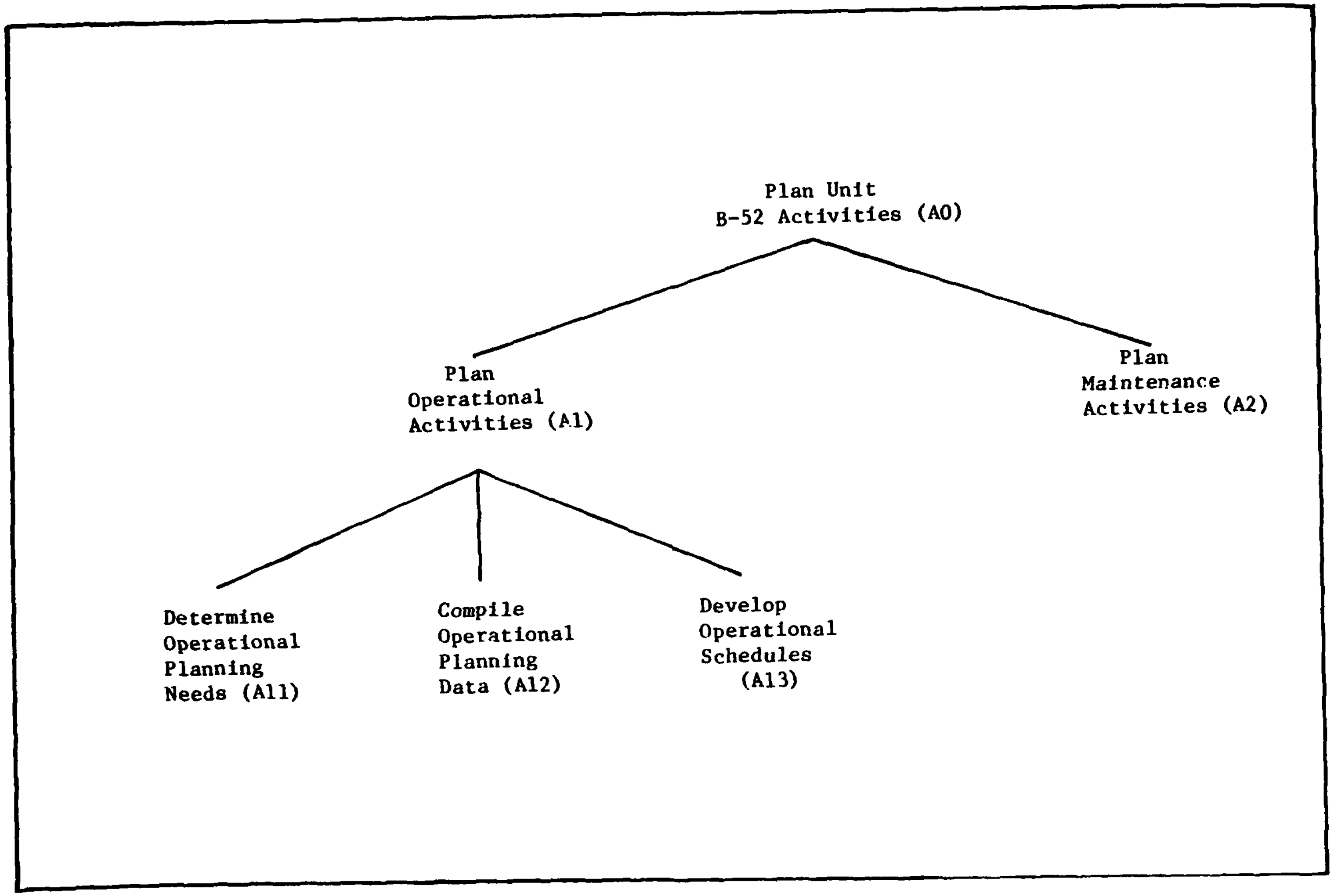

Fig 4.3. A0 Node Tree Depicting Major Subfunctions

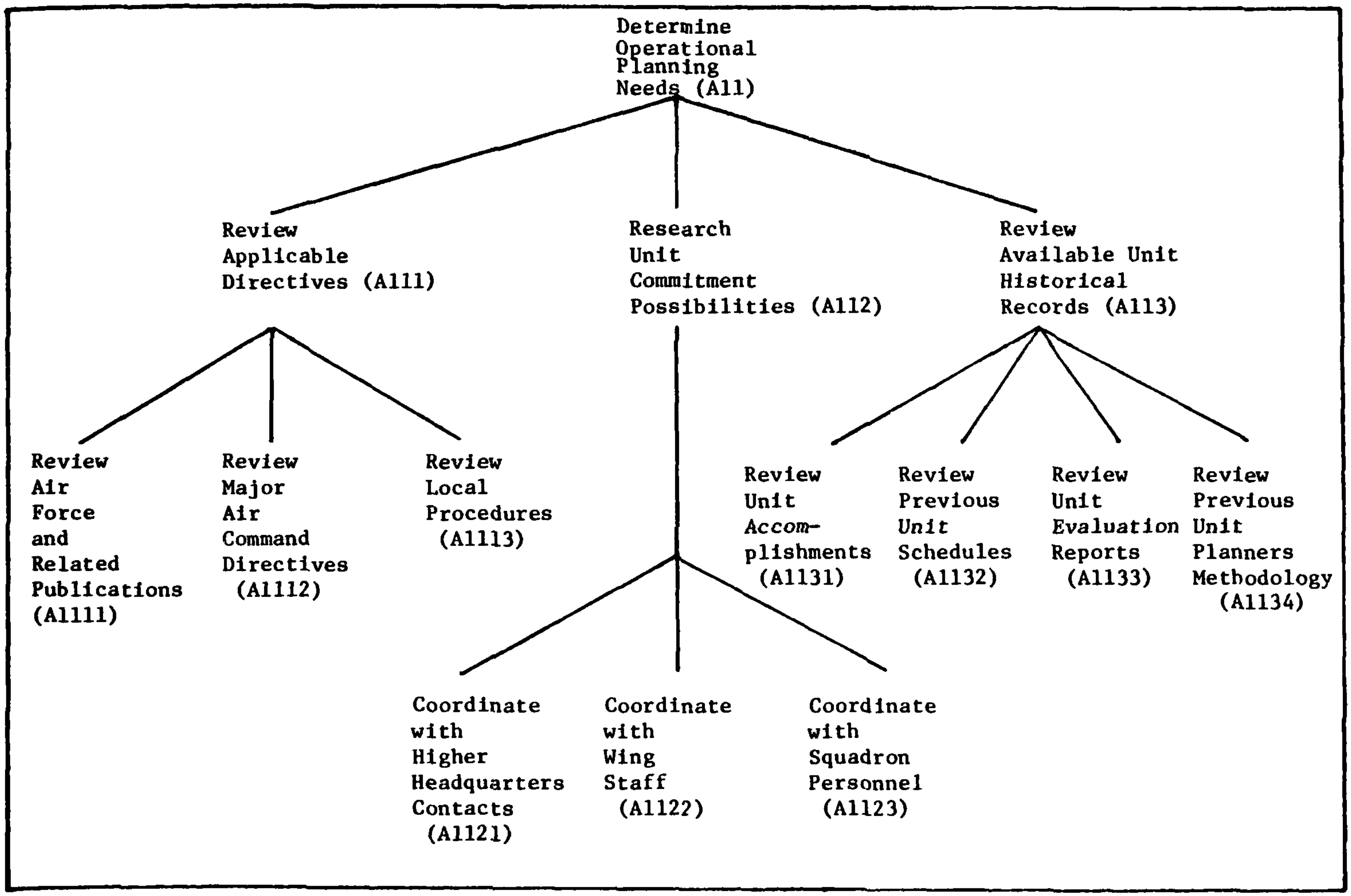

Fig 4.4. A11 Node Tree

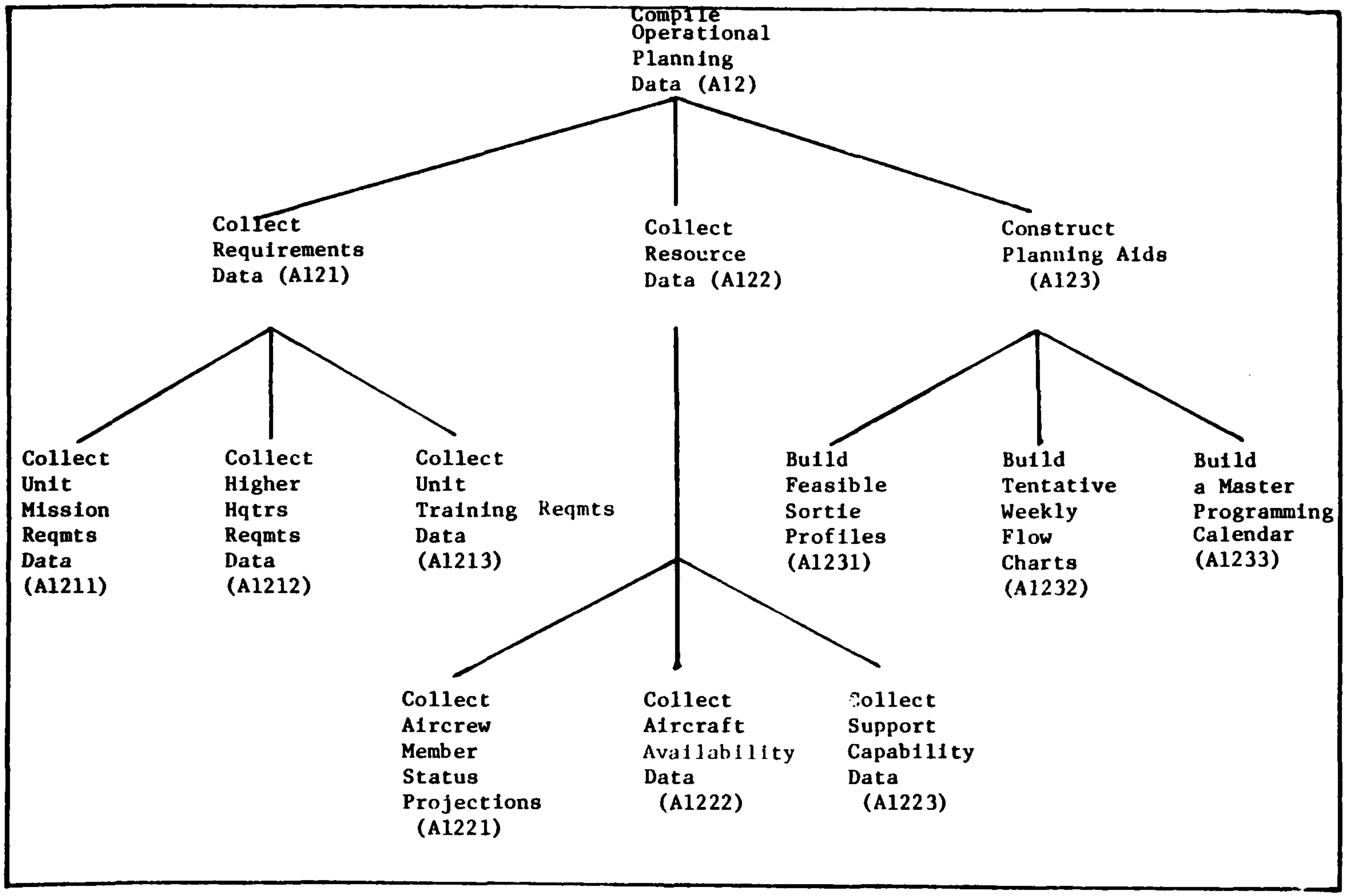

Fig 4.5. A12 Node Tree

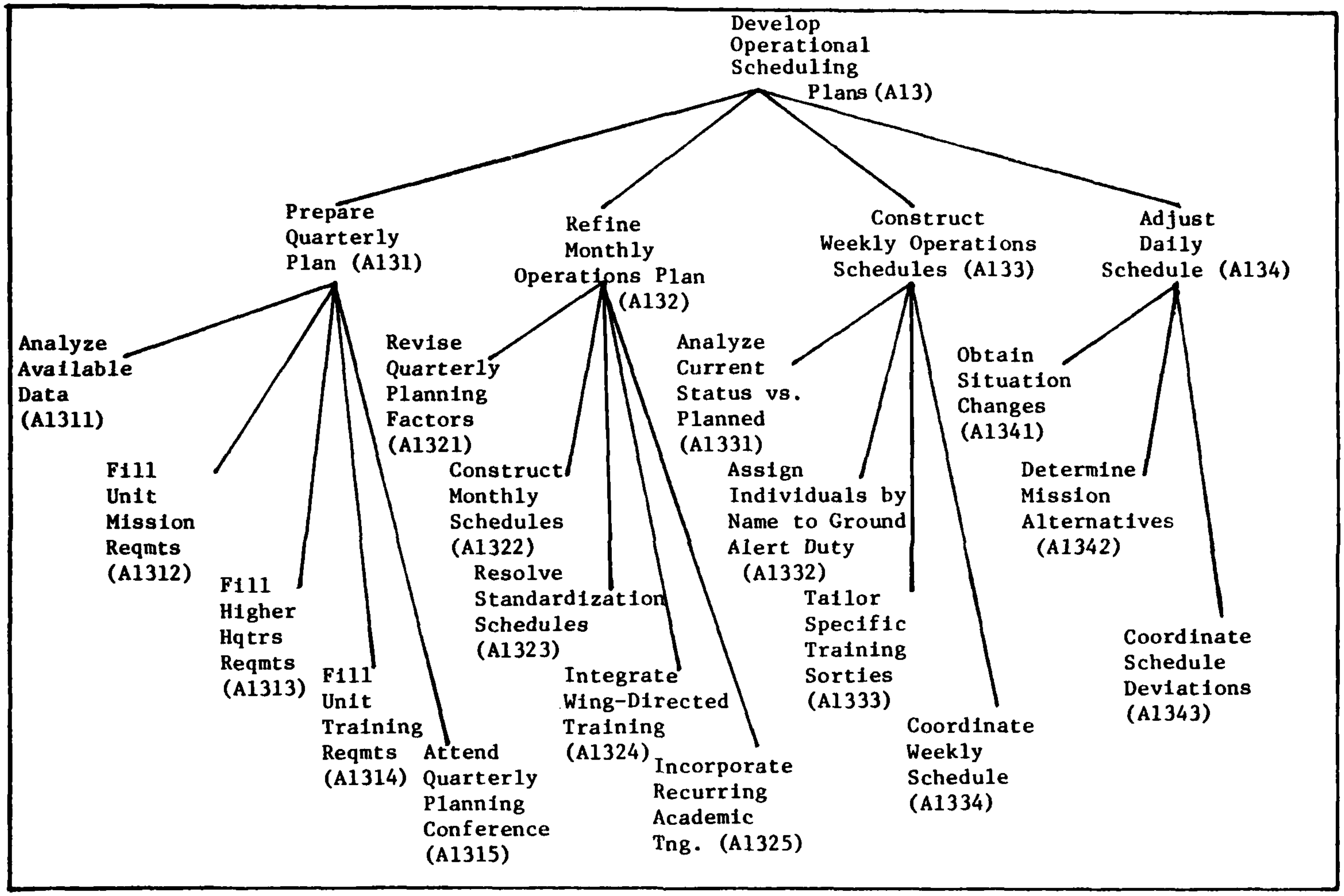

Fig 4.6. A13 Node Tree

Detailed Model Diagrams

A-0 Text. The four major areas of the unit B-52 activities scheduling model described in Figure 4.1 orientates the functional relationships between each A-0 level. Operational planning encompassing aircraft, aircrew, and maintenance resources provides the framework essential to attain unit mission objectives. The wing staff uses available information and support devices to develop a good plan consistent with command guidance and commander's prerogatives. The optimal plan allows the most efficient use of aircraft and aircrew resources while maintaining emphasis on quality as well as quantity required to support unit mission objectives.

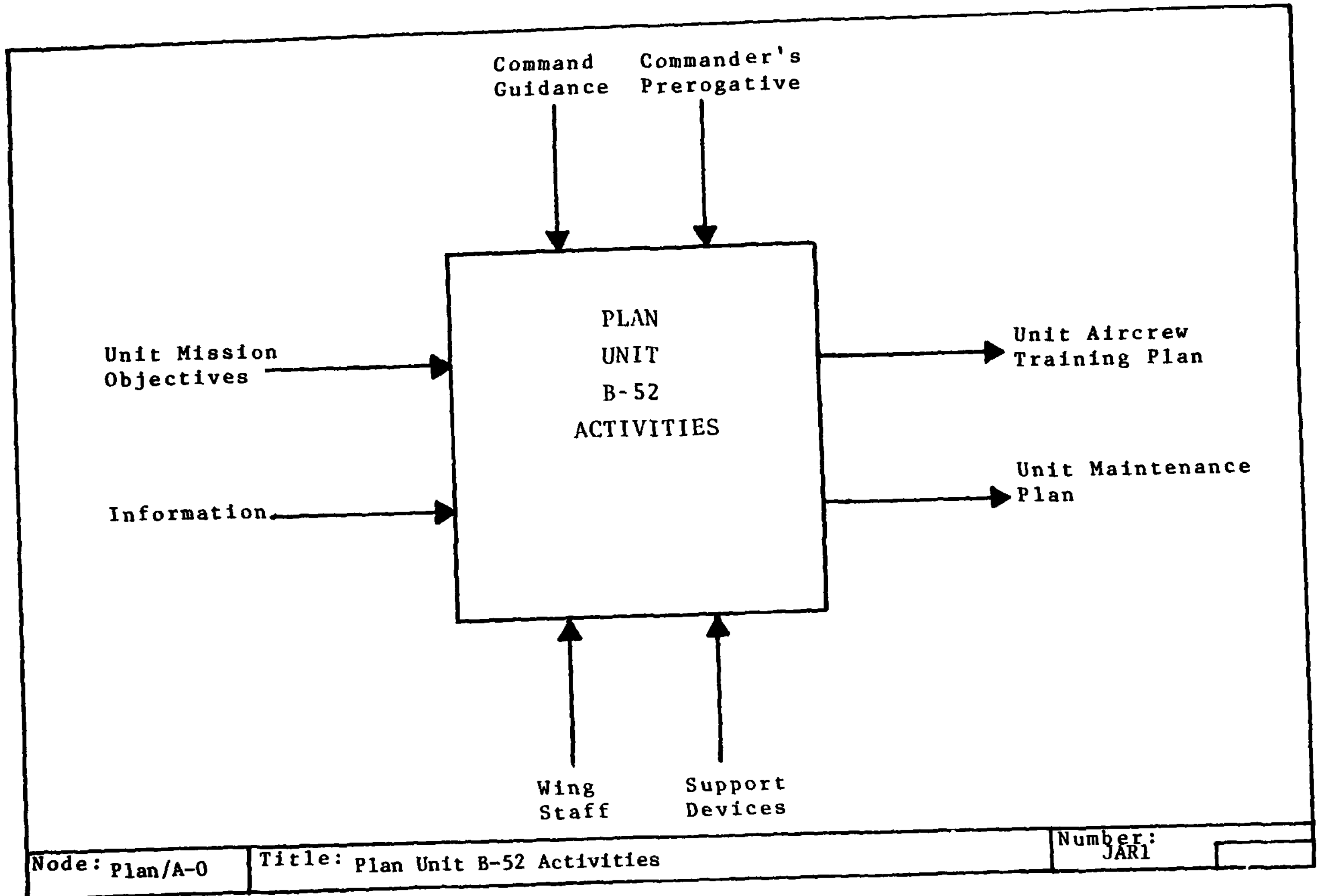

Fig 4.7. A-0 Parent Box for $IDEF_0$ Model

A0 Text. Operational requirements and maintenance capability form the basis for development of unit plans. Aircrew scheduling is the key to the planning process and influences the requirements levied upon both operations and maintenance. The unit Deputy Commander for Operations and the Deputy Commander for Maintenance insure their staffs work together in developing plans and schedules which best support unit mission objectives. Resources, such as aircraft, aircrew availability, equipment, supply support, and maintenance manning, determine the unit's ability to meet requirements. An important idea to remember is that within this functional framework, the degree of accuracy achieved in planning and scheduling the use of aircraft, aircrews, and supporting resources varies among B-52 units depending on mission, type equipment, and geographic location.

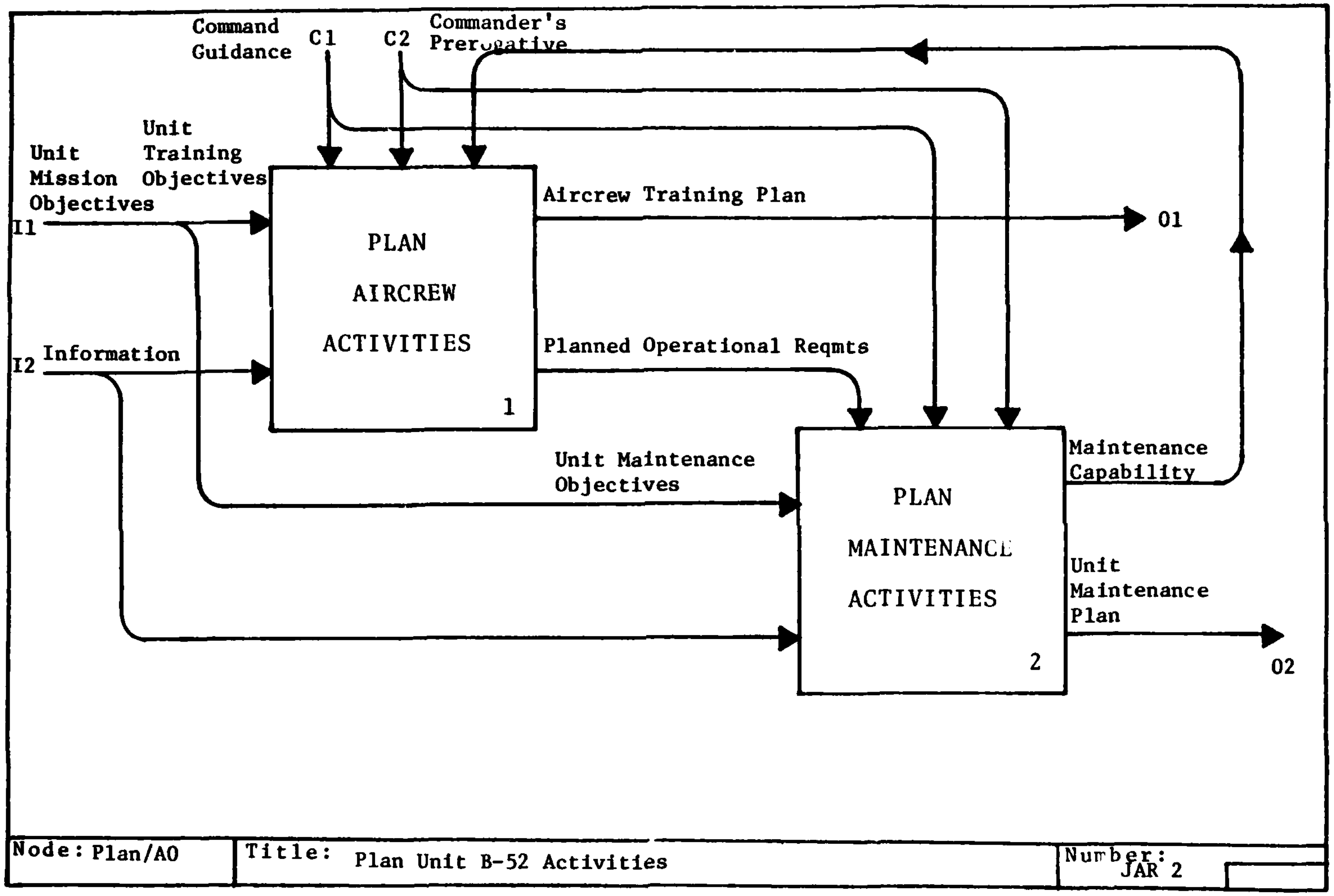

Fig 4.8. A0 Plan Unit B-52 Activities

A1 Text. The three phases involved in planning aircrew activities reflect a general decision-making scenario. First, the individuals must determine their functional responsibility. Command guidance and higher authority levels place constraints upon those planning personnel charged with training plan development. A thorough understanding of the directives mixed with a keen awareness of the other personalities involved in the planning process establish the baseline from which to initiate the scheduling procedure. Once knowledgeable with the job information requirements, the next major effort is to collect the available information required to construct a viable training plan. After the information is gathered and assimilated from diverse sources, the unit planner uses it to build a quarterly plan that receives considerable modification as more information becomes available. Several plans result from this procedure in an effort to ensure the efficient allocation of resources toward unit training objectives.

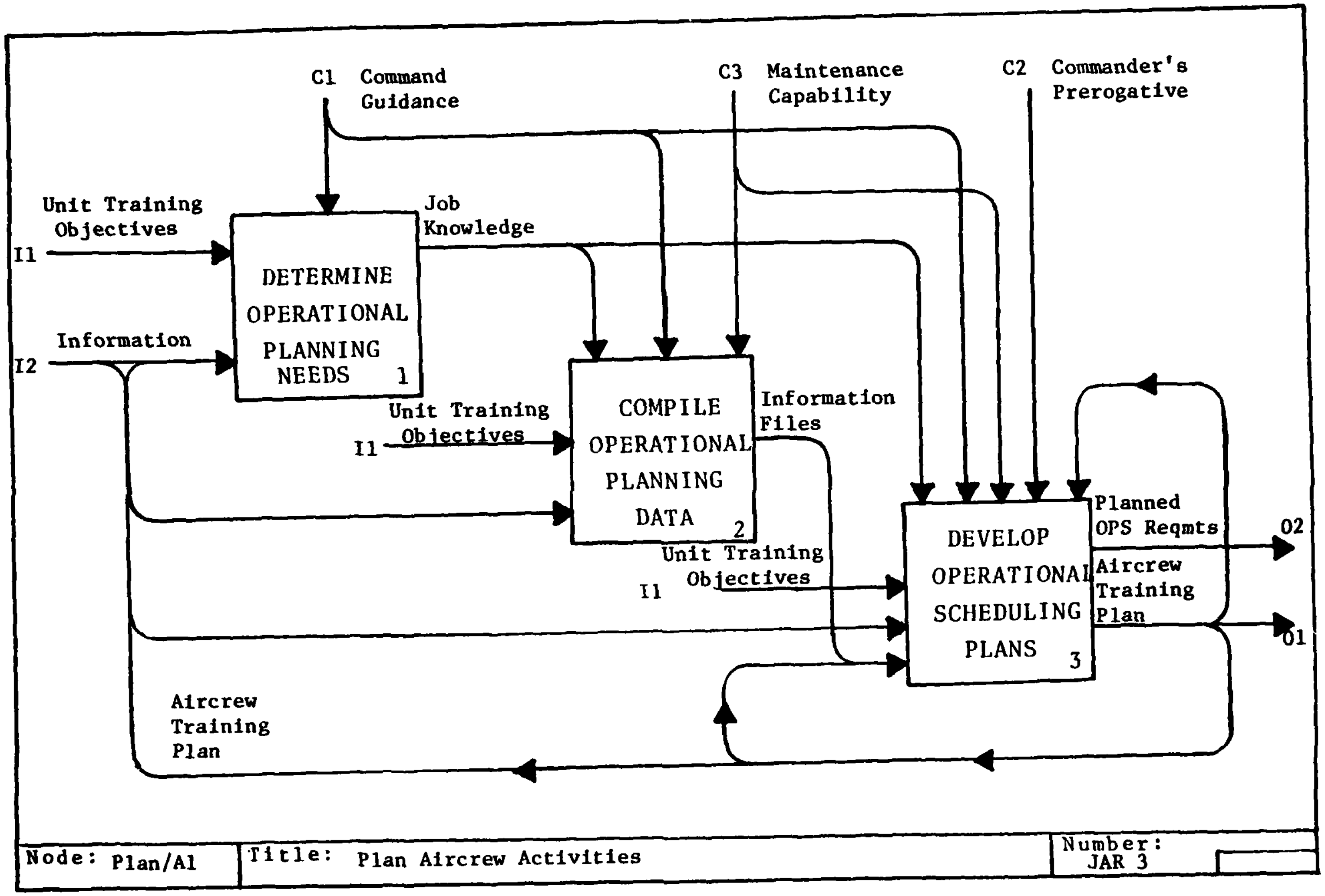

Fig 4.9. A1 Plan Aircrew Activities

All Text. Unit planners obtain part of their job expertise through the study of those documents, regulations, and procedures related to B-52 scheduling activities. Command guidance toward scheduling parallels the Air Force's organizational structure. Broad general guidelines come from the Air Force hierarchical level and are narrowed to quite specific local unit procedures. Another vital segment of the unit planner's education is to explore the universe of commitments the unit could be tasked with during the planning period. The interaction with all immediate control echelons promotes idea exchange vertically within the command. The final element in determining operational planning needs involve looking at the unit historical accomplishments. A critical consideration of past unit capabilities, evaluated with causes for modifying original plans, mixed with previous unit performance deficiencies help narrow the informational needs required to accomplish the planner's task. A survey of the methods previous planners used to accomplish the unit planning functions caps the preliminary steps in acquiring job knowledge for planning unit B-52 activities.

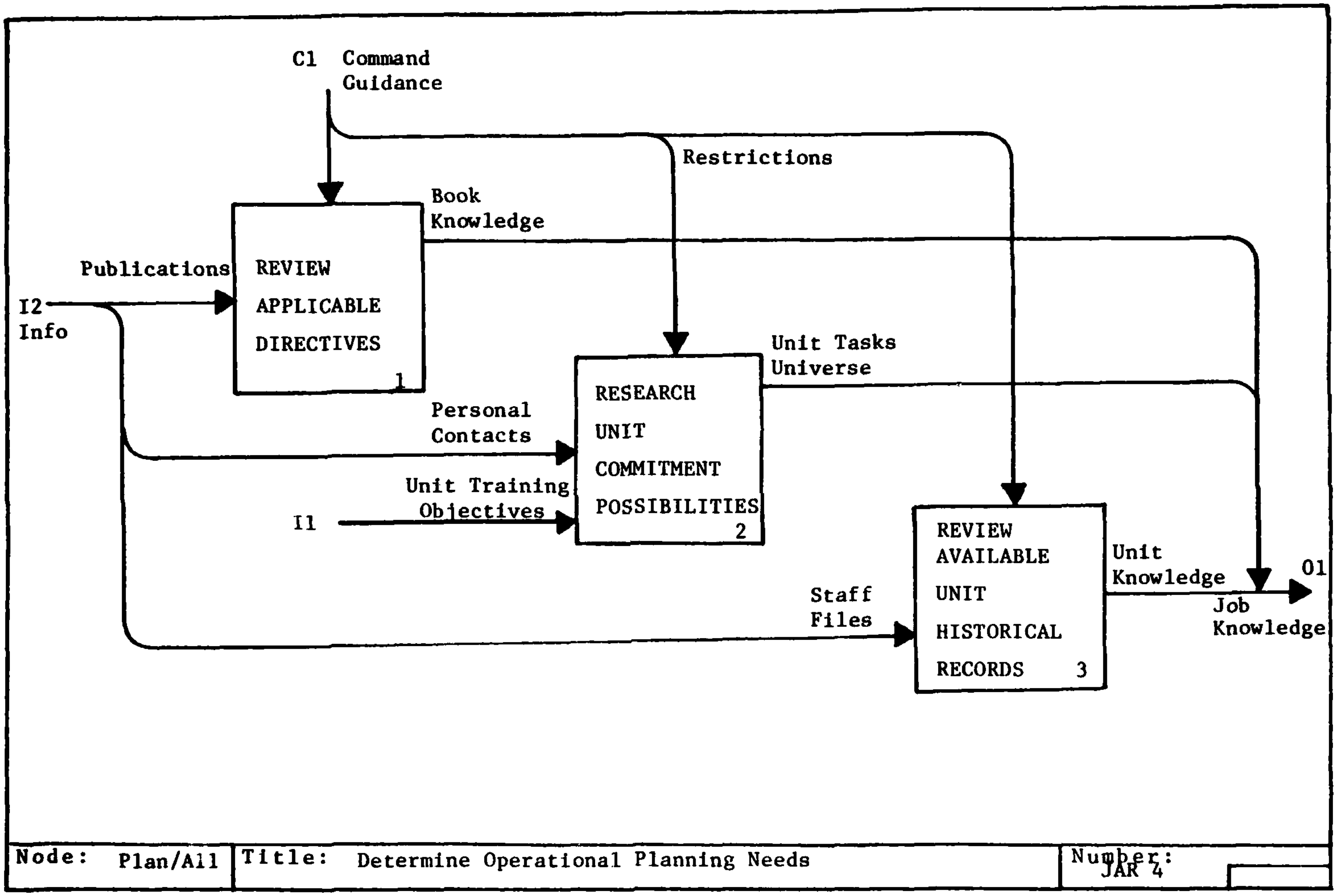

Fig 4.10. All Determine Operational Planning Needs

A111 Text. An approach to acquire book knowledge concerning B-52 planning activities consists of studying the broad policies established by the Air Force. These include general flight operations and restrictions, aircrew requirements and qualifications, and general support necessary to accomplish aircrew training. Related documents published by the Department of Defense, Federal Aviation Administration, and executive branch provide basic direction for aircrew planning. Major Air Command rules focus, within the broader Air Force context, upon those weapon systems assigned to its control. The narrowed procedures from the Strategic Air Command supplemented by Numbered Air Force, Air Divisions, and specialized local procedures constitute the bulk of book knowledge available to the unit planning staff.

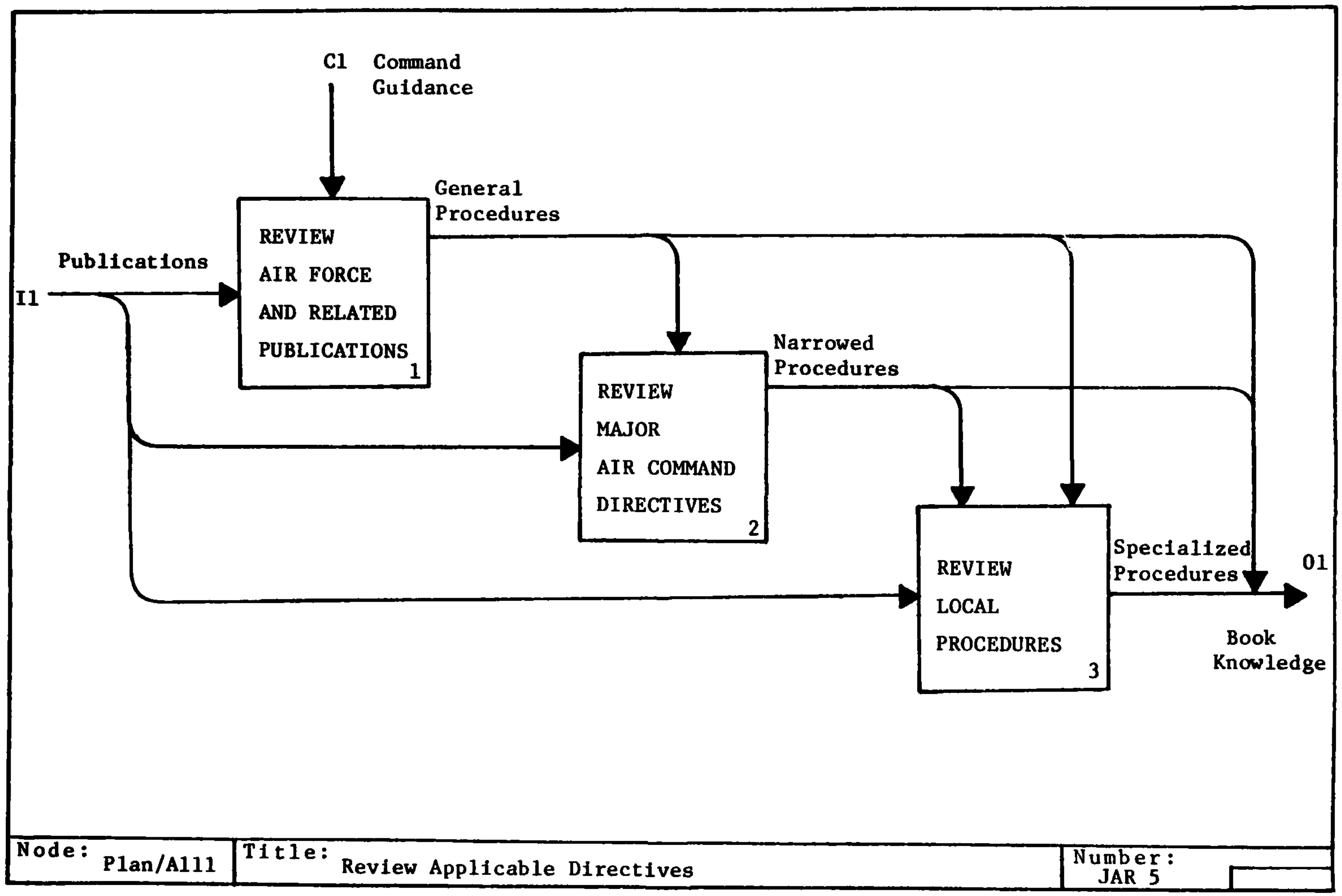

Fig 4.11. A111 Review Applicable Directives

A112 Text. An integral part of the planning process involves the information exchanged between the hierarchical levels. During the early stages, unit planners maintain numerous personal contacts with individuals functioning in higher authority levels. Thus they ensure unit commitment plans receive attention at the headquarters level. Also, the contacts help unit planners keep abreast of new ideas receiving command attention. Unit planners who use their expertise in maintaining appropriate personal contacts can enhance a unit's planning effectiveness. Planning improvement occurs from the standpoint that the planners find out earlier about the panorama of commitments the unit might be tasked to accomplish.

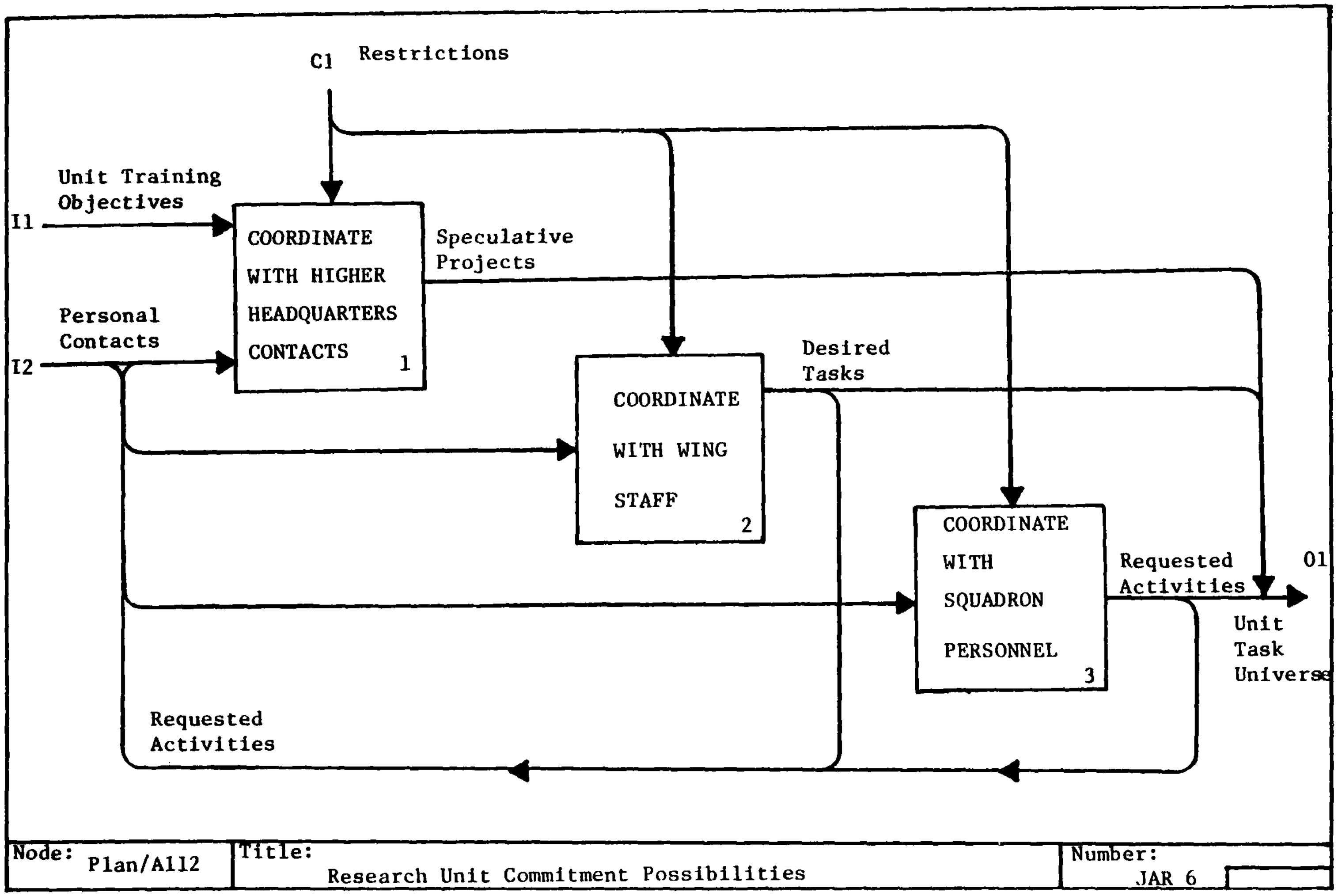

Fig 4.12. A112 Research Unit Commitment Possibilities

AD-A123 023 A SAC B-52 AIRCREW SCHEDULING MODEL USING ICAM'S IDEF METHODOLOGY(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. J M MOORE ET AL. SEP 82 2/2

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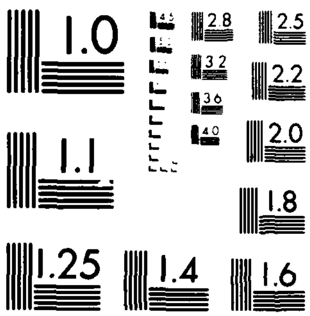

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

A113 Text. Unit schedulers capstone the B-52 planning preparation by reviewing past unit accomplishments. The historical facts help limit and bound the scope of operational activities. By studying plan refinements and changes, a scheduler learns what things usually cause deviations from planned activities. Other important information sources to the novice planner are the reports, resulting from higher headquarters evaluations and visits, documenting unit performance. Just as unit performance does not remain constant, neither do the techniques used to plan unit B-52 activity. Unit schedulers may achieve a broader perspective toward unit planning by perusing the previous techniques employed by their predecessors.

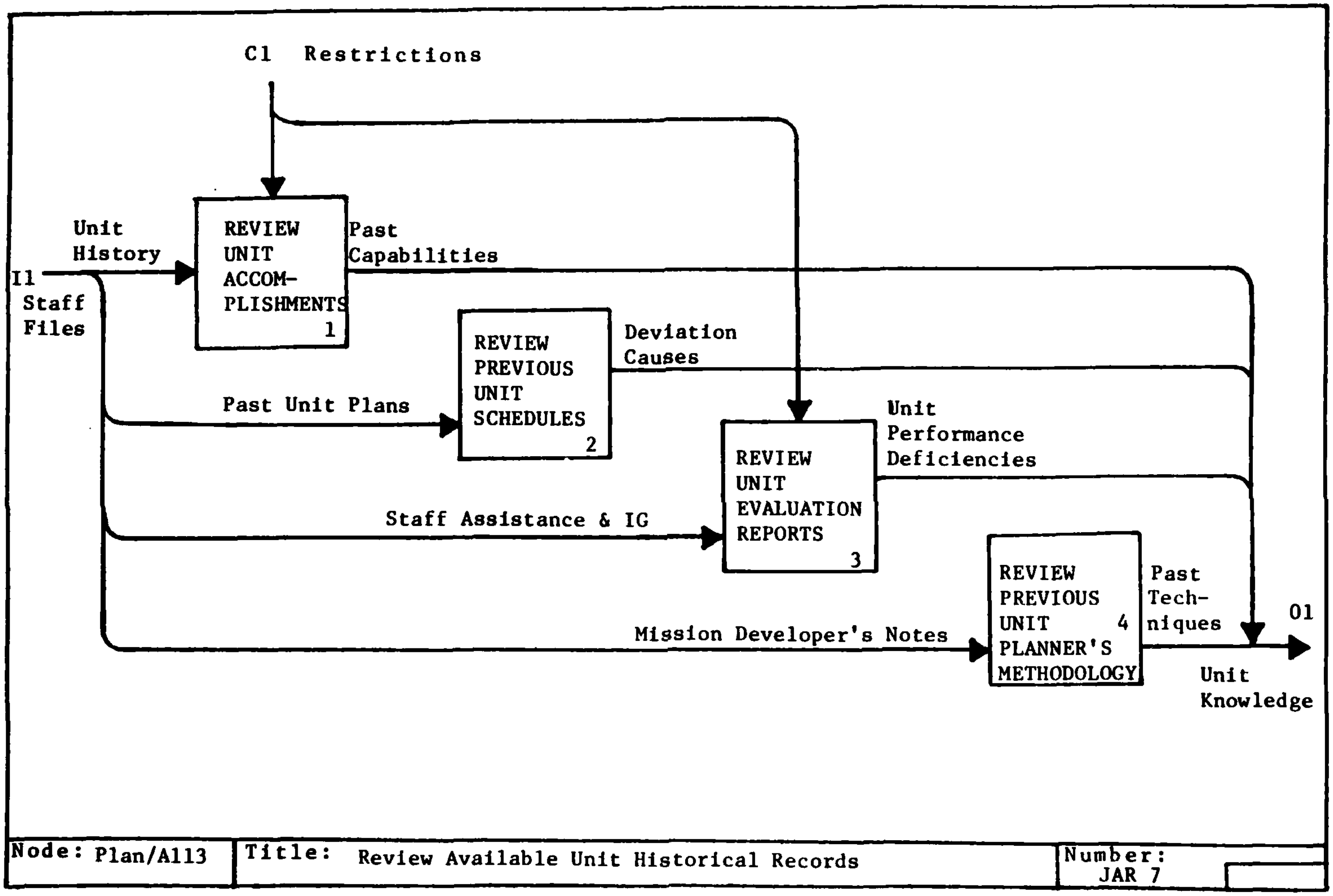

Fig 4.13. A113 Review Available Unit Historical Records

A12 Text. The second of three major subdivisions within the planning unit B-52 activities focuses on the information collection process. The general effort involves collecting requirement and resource information. Operating within command guidance and job knowledge limitations, unit planners couple established unit training objectives with available information to determine known unit tasks. Unit planners consider maintenance capability as an important unit resource. Continuous communication between operations and maintenance staff planners ensures the most current information remains available to schedulers in their task of constructing planning aids for developing unit schedules.

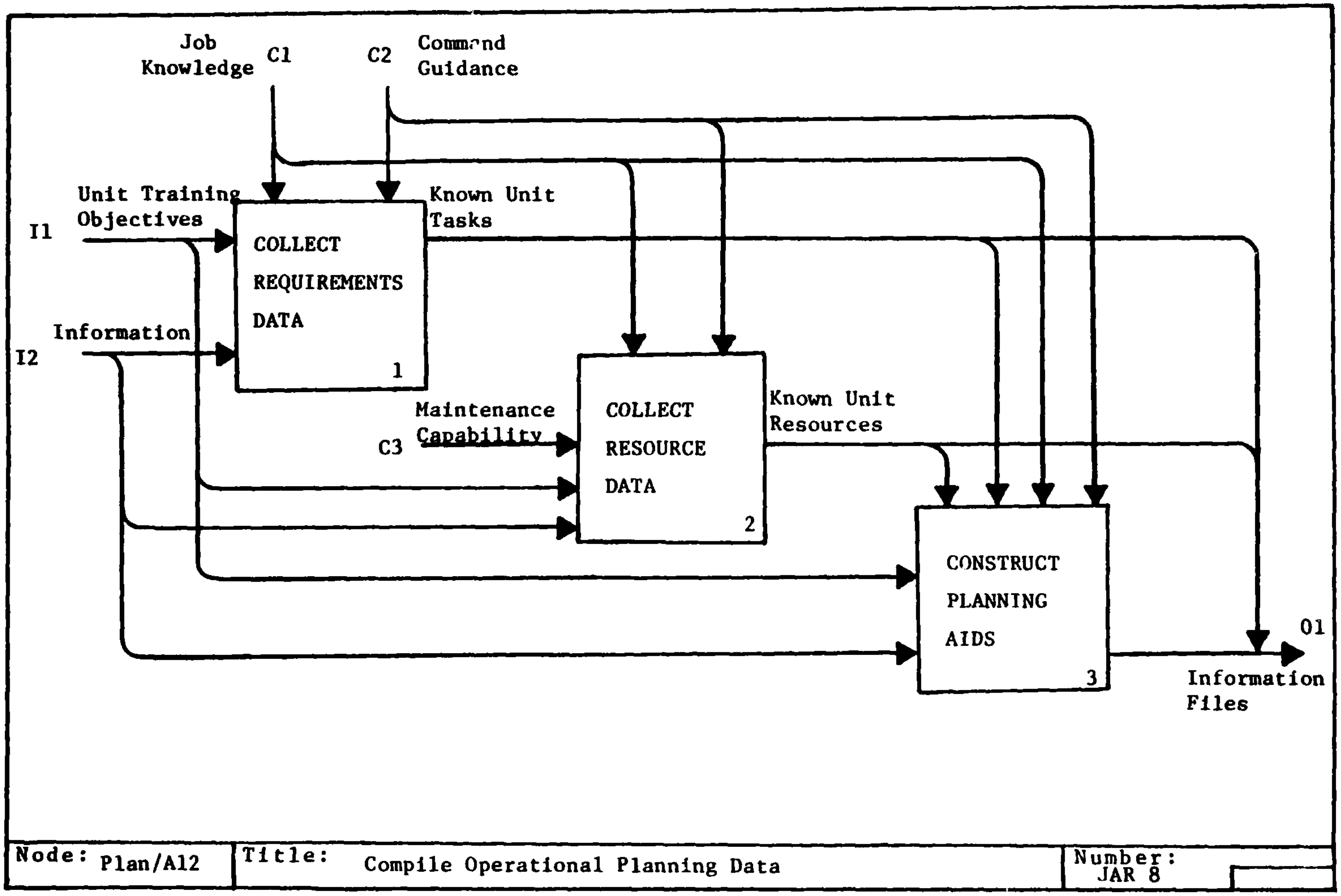

Fig 4.14. A12 Compile Operational Planning Data

A121 Text. The collection of unit requirements information includes establishing the unit's mandatory tasks to which resources must be committed on a first priority basis. Some examples of required data are: the number of qualified aircrews the unit must maintain, how many ground alert aircraft the unit must man, and the required number of sorties as detailed in the unit's Flying Program Document. Higher headquarters commitments affecting the unit planning process include special missions, depot maintenance schedules, and any known or recurring commitments. Data elements for unit training requirements involved in continuation/initial/ upgrade and unit-directed training all contribute to the known unit tasks.

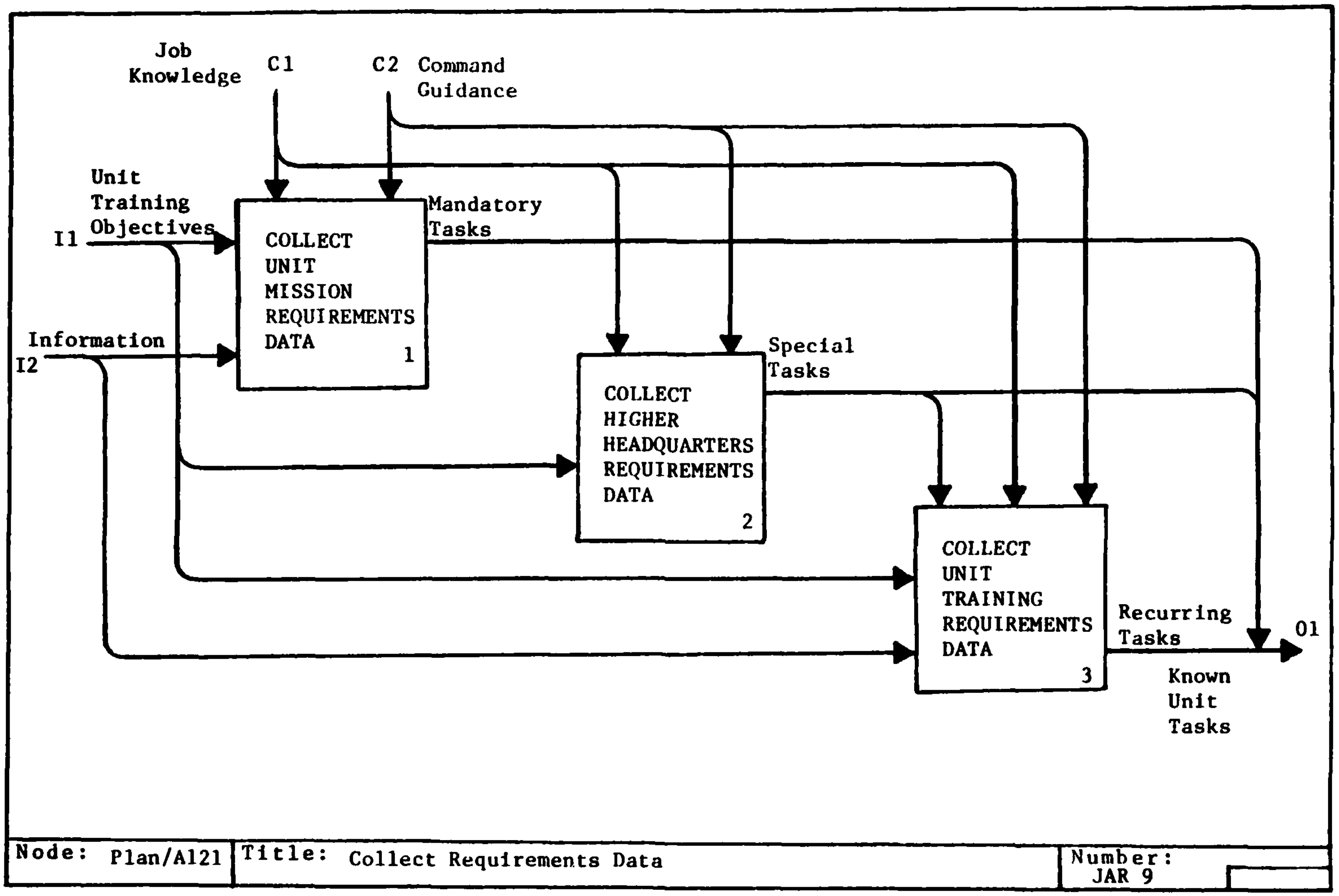

Fig 4.15. A121 Collect Requirements Data

A122 Text. Each unit conducts a monthly meeting to assess the unit's personnel. The projected personnel gains/ losses to the unit plus all other factors affecting an air- crew member's availability receive primary staff attention. Maintenance manpower authorizations in most SAC units fall short in providing the unit full maintenance coverage twenty-four hours a day. Effective maintenance scheduling distributes work effort into two daily work shifts. Support capability is affected by aircraft availability. This capa- bility is a function of the detailed and timely planning by Numbered Air Forces (NAFs) to allocate Strategic Training Ranges (STR) and HQSAC to allocate air refuelings consistent with each unit's two daily maintenance shifts.

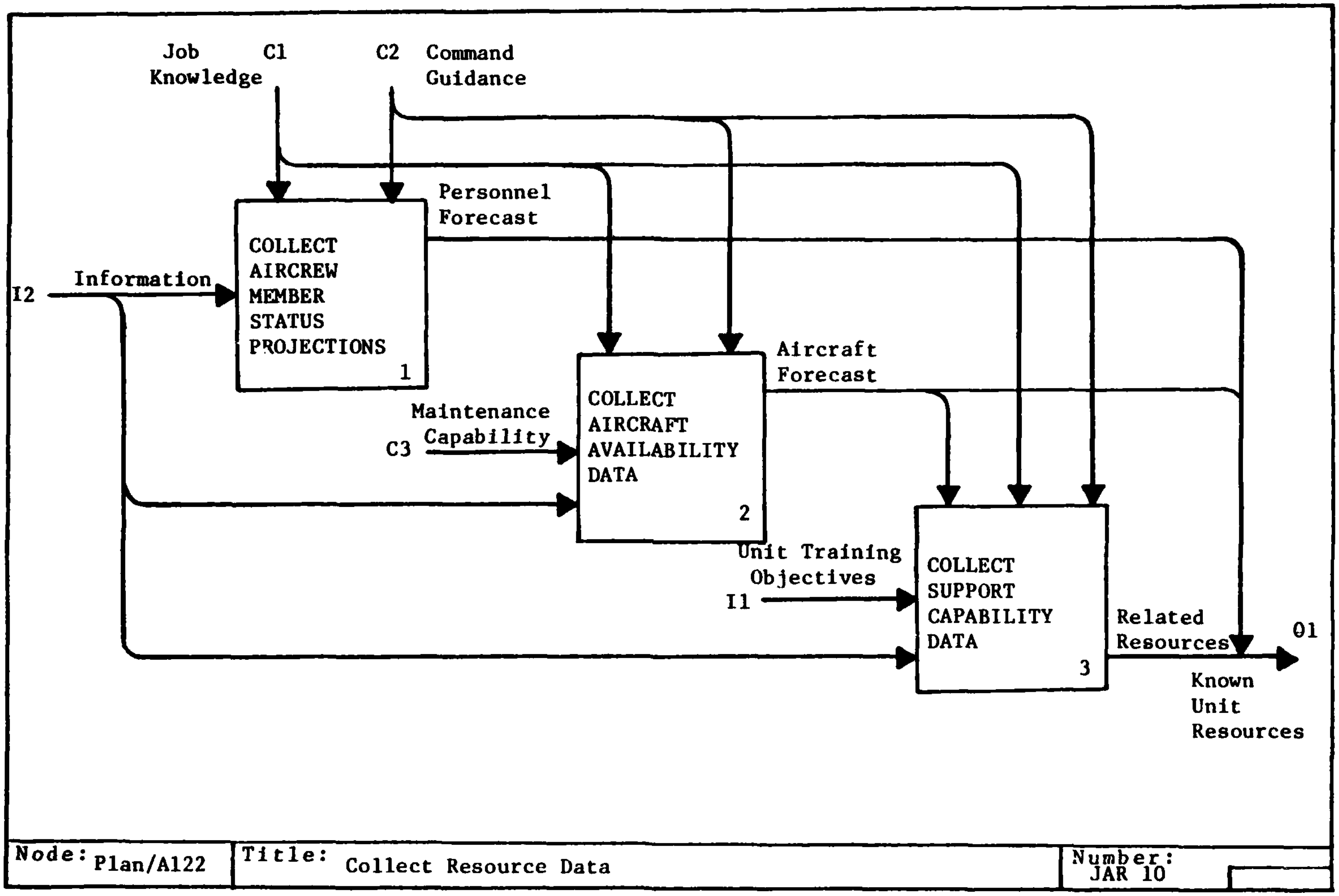

Fig 4.16. A122 Collect Resource Data

A123 Text. The accumulation of requirement and resource data provide the primary input into the planning aid construction phase. Each scheduling branch, assisted by the bombing/navigation branch, defensive systems branch and tactical squadrons, develop mission training packages designed to meet the unit training objectives within the allocated flying time. During the creation of weekly flow charts, unit planners incorporate several scheduling techniques used to maximize sorties while achieving the best use of resources. A master programming calendar for the training period being planned serves as an aid for arranging and evaluating different informational combinations during actual schedule construction phases.

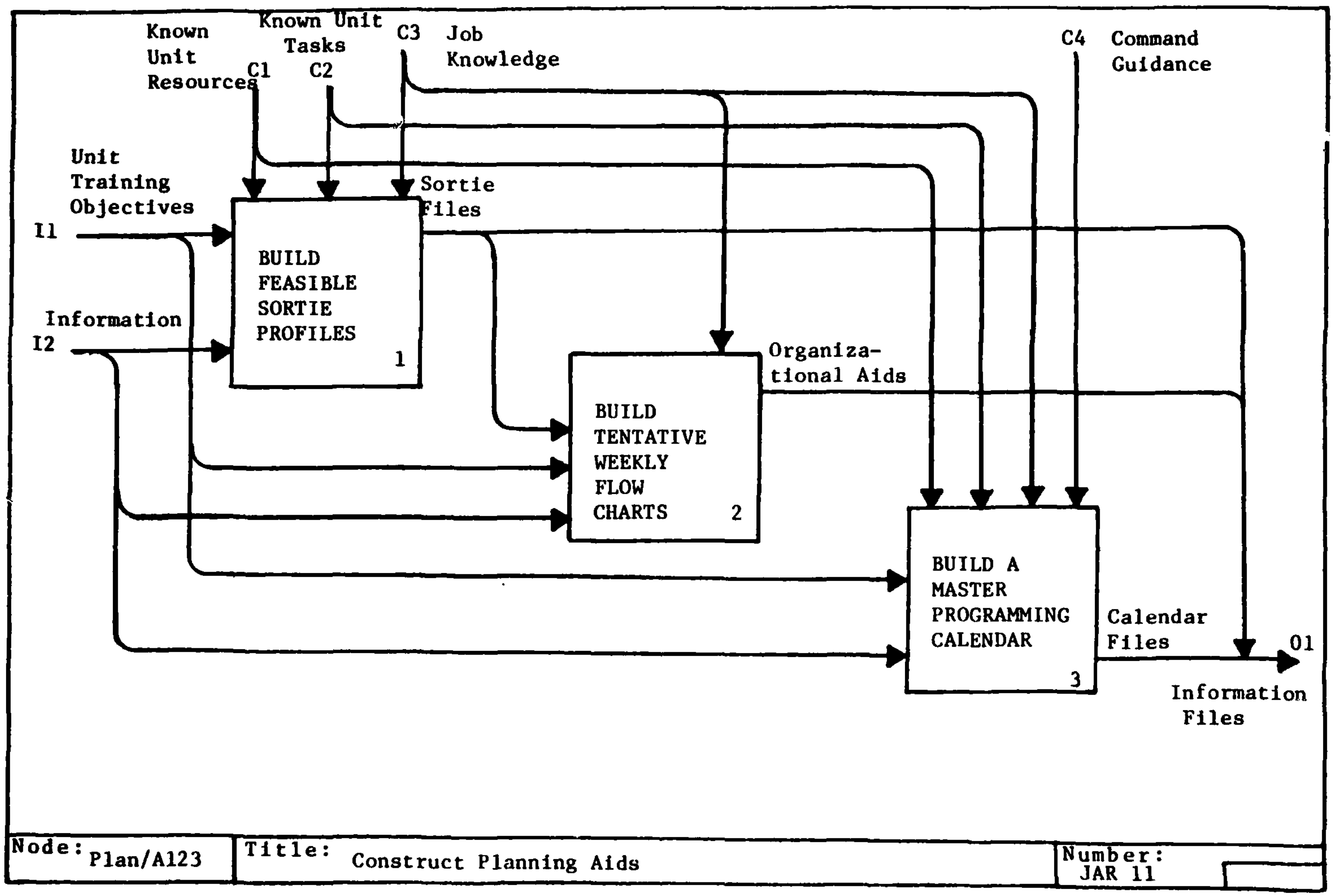

Fig 4.17. A123 Construct Planning Aids

A13 Text. A clear stop information collection/sta-t operational schedule development line does not exist. Information acquisition continues throughout the entire planning process as the quarterly unit plan receives monthly, weekly, and daily refinements. It is through this continuing process of addition and refinement, in coordination with the unit maintenance staff, that the plan is developed into a final program. It is within this third major functional planning subdivision that the constraints dominate the model. The controls range from the planner's actual job knowledge to required procedures from higher authority levels to shortfalls in maintenance capability to meet operational requirements. Within this constrained working environment, the unit planners attempt to improve upon the imperfect knowledge available as they endeavor to efficiently allocate resources to operational requirements in partial fulfillment of wing mission objectives.

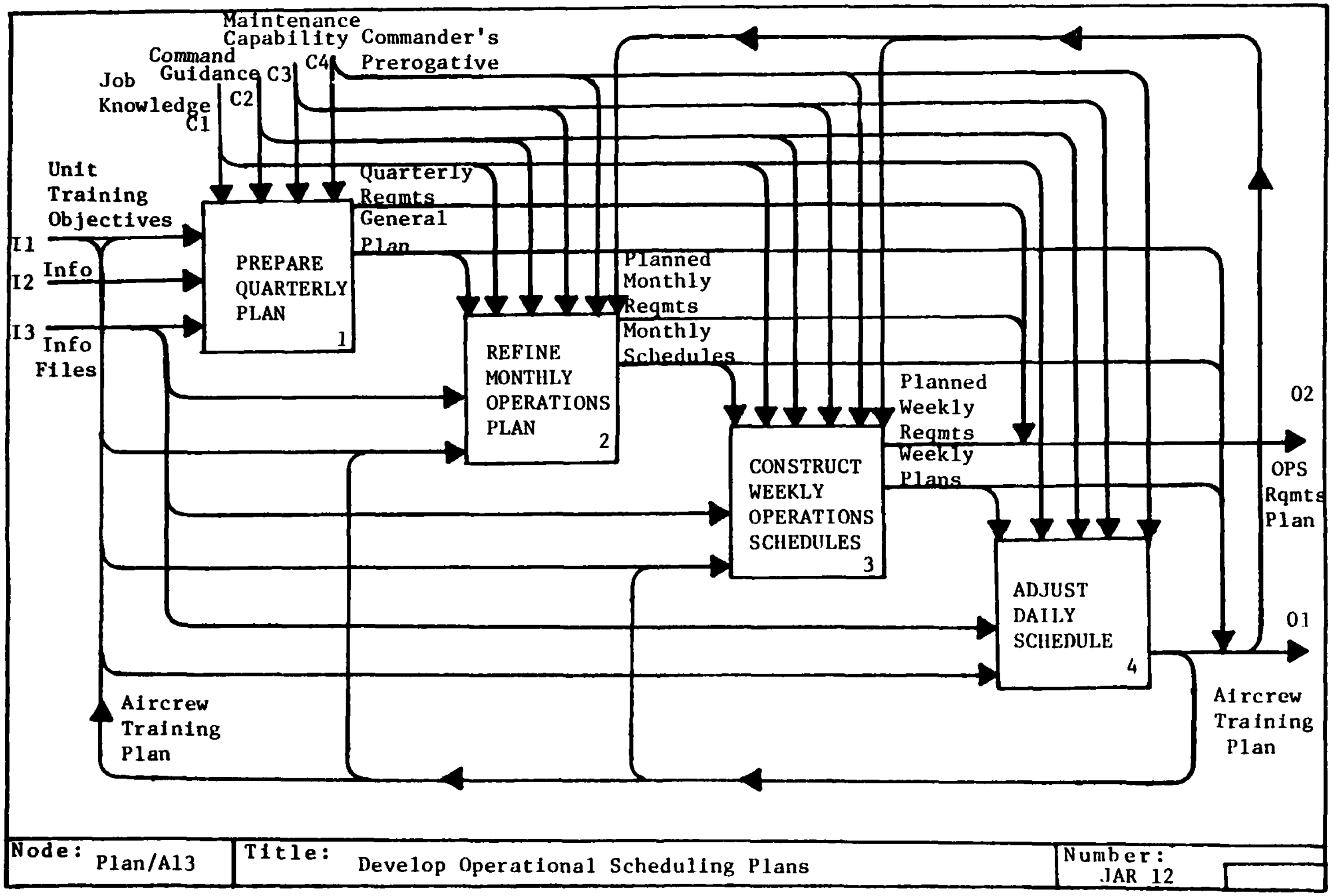

Fig 4.18. A13 Develop Operational Scheduling Plans

A131 Text. The quarterly plan is the key to a good unit plan. Two vital information elements the unit receives are Strategic Training Range (STR) and air refueling allocations. Based upon these two controlling informational bits, the quarterly plan embodies launch/recovery blocks, sortie flow timing, and effective sortie scheduling techniques such as performing safety of flight maintenance actions between sorties, engine running crew change, and flying through the maintenance dead shift. The period starting about seven weeks prior to the quarterly training period consists of active negotiations between operations and maintenance planners. In most units, differences in operational requirements and support capabilities are resolved, culminating with a tentative plan formulation. Unit planners coordinate the plan with the unit commander before unit representatives attend the quarterly STR/Air Refueling Scheduling Conference. Subsequent alterations to the plan stemming from the conference receive attention during a quarterly planning meeting chaired by the unit commander. In this meeting operational requirements, support capabilities, and any expected difficulties are discussed.

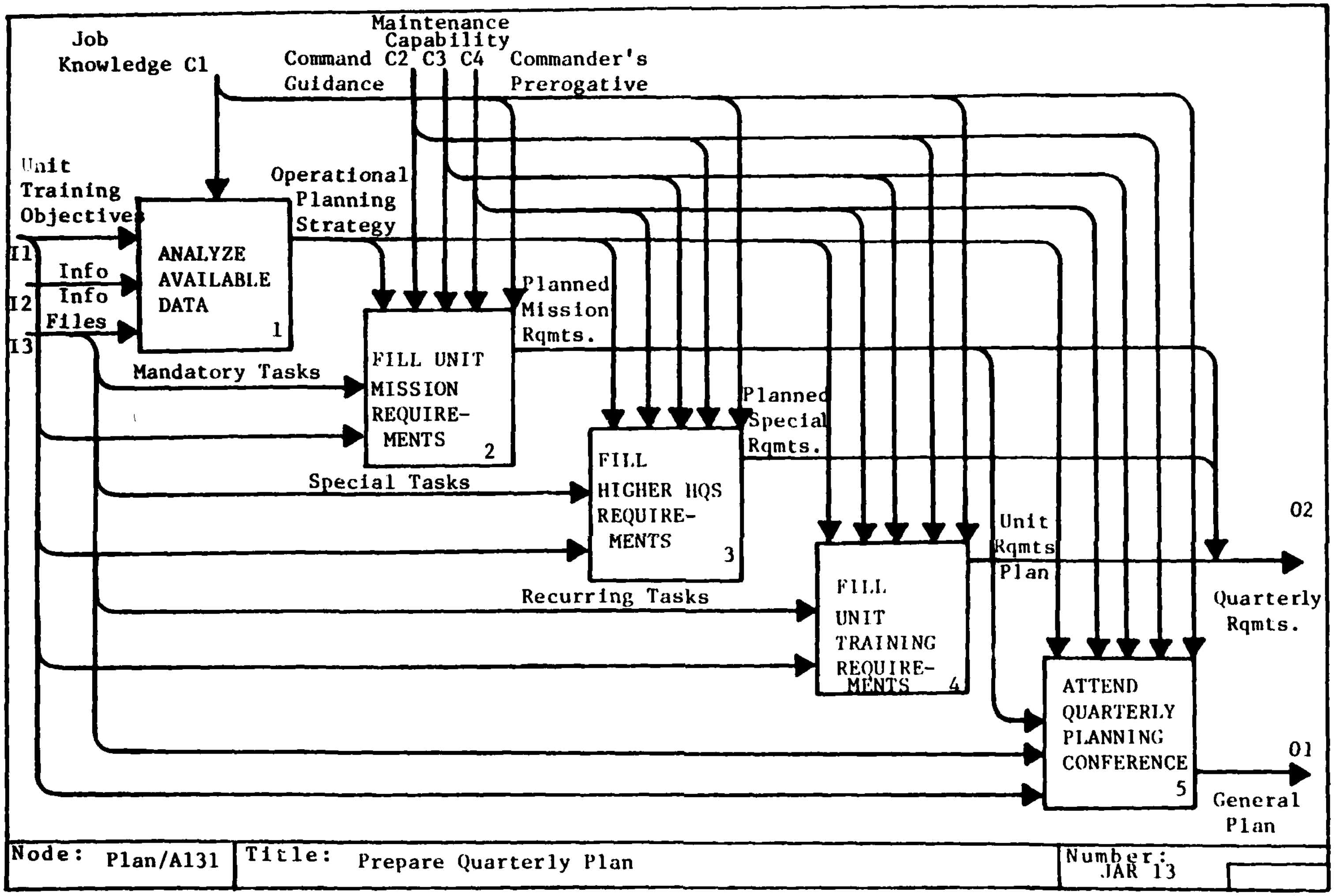

Fig 4.19. A131 Prepare Quarterly Plan

A132 Text. Monthly planning further refines the requirements established during the quarterly planning period. The two outputs, resulting from the foundation established by close coordination between operations and maintenance planning staffs, are the monthly maintenance plan described by Hackett and Pennartz (1982) and the monthly operations plan. Within the monthly operations plan appears a basic plan outlining the operations plan, training priorities, and training goals. Revision of the quarterly planning factors include incorporating quarterly flying hour allocation changes. This leads to a reforecast of monthly sortie rates and flying hour expenditures. Planners forecast the number of crews available for the training, all known temporary duties, higher headquarters missions, and squadron/staff leave schedules for the upcoming three months. The monthly schedules include a working, semi-final and final schedule. The standardization schedule incorporates required evaluations of flight personnel for the next three months into the normal training flow. This is accomplished by matching the individual crew member with a training sortie profile meeting evaluation requirements and by assigning an evaluation of like-crew specialty to the sortie. Wing-directed training involves additional unit requirements to compensate for individual differences in experience/proficiency, to correct deficiencies identified by higher authority level evaluations, or to train for specialized unit tactics/procedures. Operations flight and ground planners ensure recurring academic training, such as annual physicals and physiological training mesh with all other scheduled monthly unit B-52 activities.

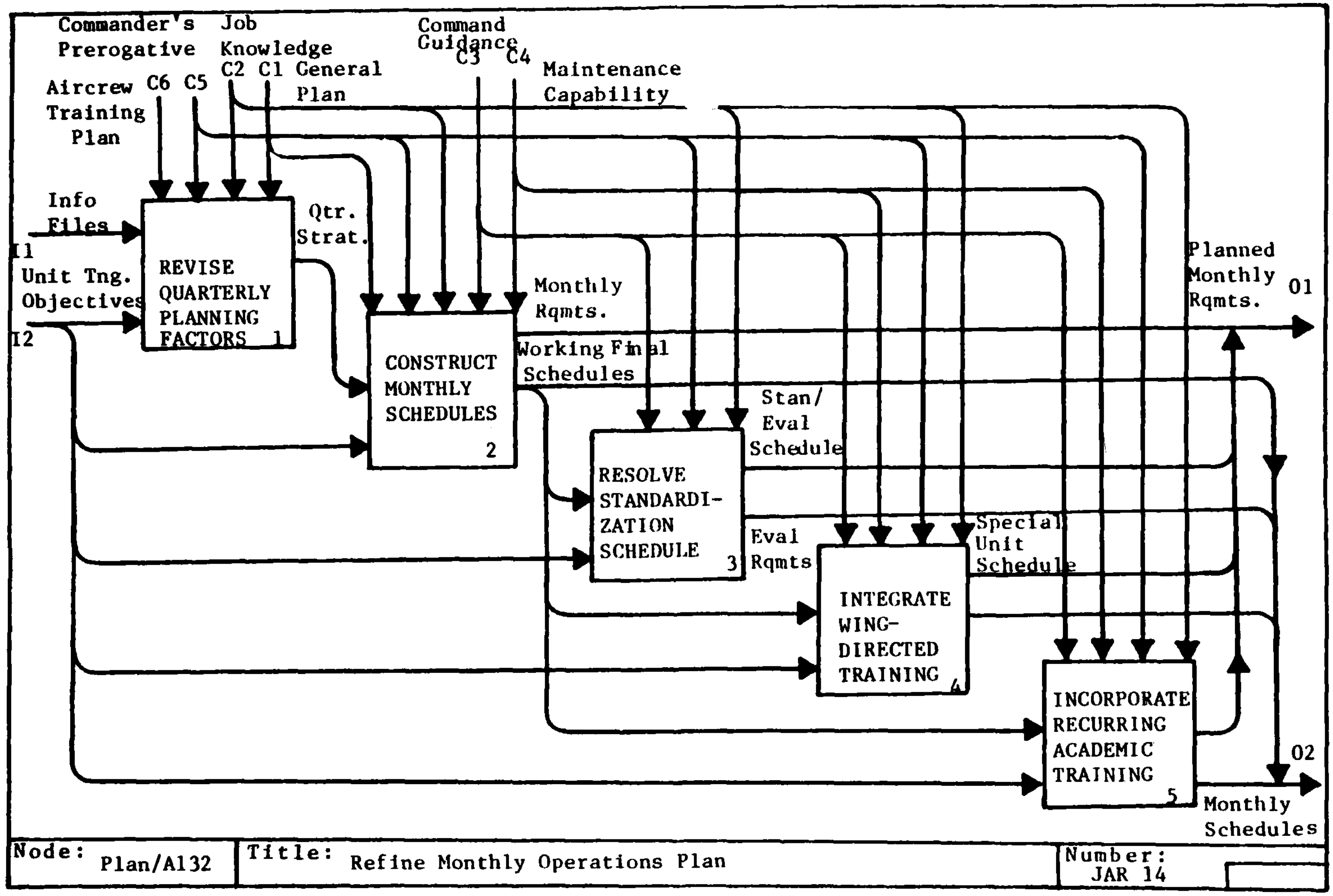

Fig 4.20. A132 Refine Monthly Operations Plan

<u>A133 Text</u>. A weekly schedule refines the monthly maintenance and operations plans. Generally the plan covers the period from Monday through Sunday, while detailing both operations and maintenance needs. A planner cannot simply isolate one particular weekly schedule. The primary reason is because alert changeover for B-52 aircrews occur on Thursdays each week. Thus, for each week of flying activity scheduled, two weeks of alert must be planned. The informational model for assigning aircrew personnel by name to ground alert duty is presented in Chapter 5 of this work. The real negotiations and tough decisions usually occur during the weekly planning meetings, especially if preceded by poor quarterly or monthly planning or if major changes to the original plan occur. Once approved by the unit commander, the weekly flying schedule and an agreed upon weekly maintenance schedule incorporating the approved aircraft utilization schedule are published. Weekly schedules provide the final planning guide for operations and maintenance.

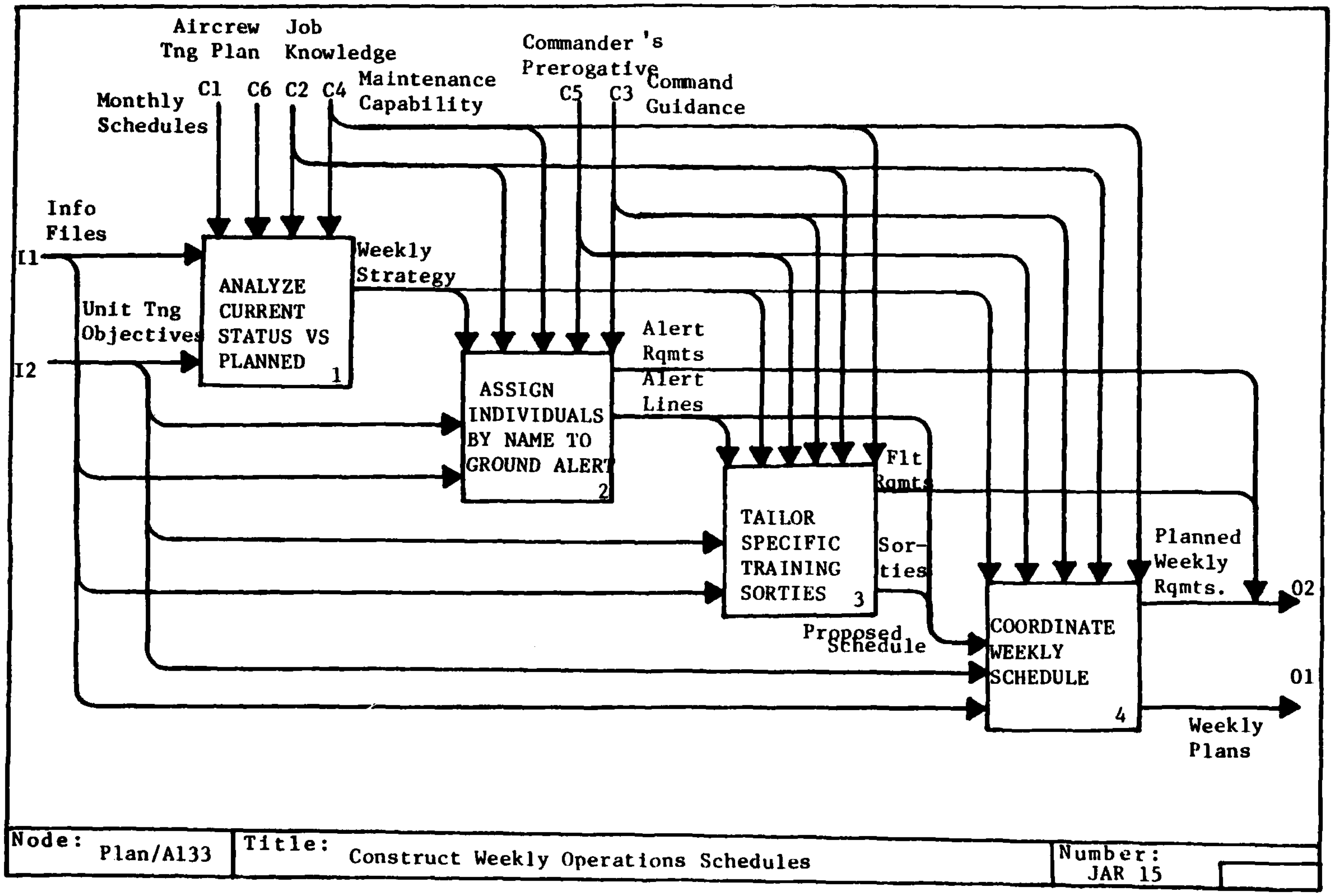

Fig 4.21. A133 Construct Weekly Operations Schedules

A134 Text. Between the final planning guide found in the weekly flying schedule and actual plan implementation, situational changes occur. Crew members become ill, aircraft components fail, weather conditions affect safe aircraft operation, or the unit receives a higher headquarters no-notice evaluation. These and similar unplanned occurrences require deviations from the original schedule. Schedulers present alternative courses of action to the decision-makers, who in turn make decisions which provide the best opportunity of reaching the original unit objectives. Once a change is approved, all those affected by it must be notified. Each unit uses a notification plan or system to ensure the change reaches all appropriate individuals and organizations prior to the plan implementation. Changes are recorded on the published schedules to be used as informational sources during the implementation phase. Also, the annotations serve as major inputs to the evaluation phase of accomplish unit B-52 activity.

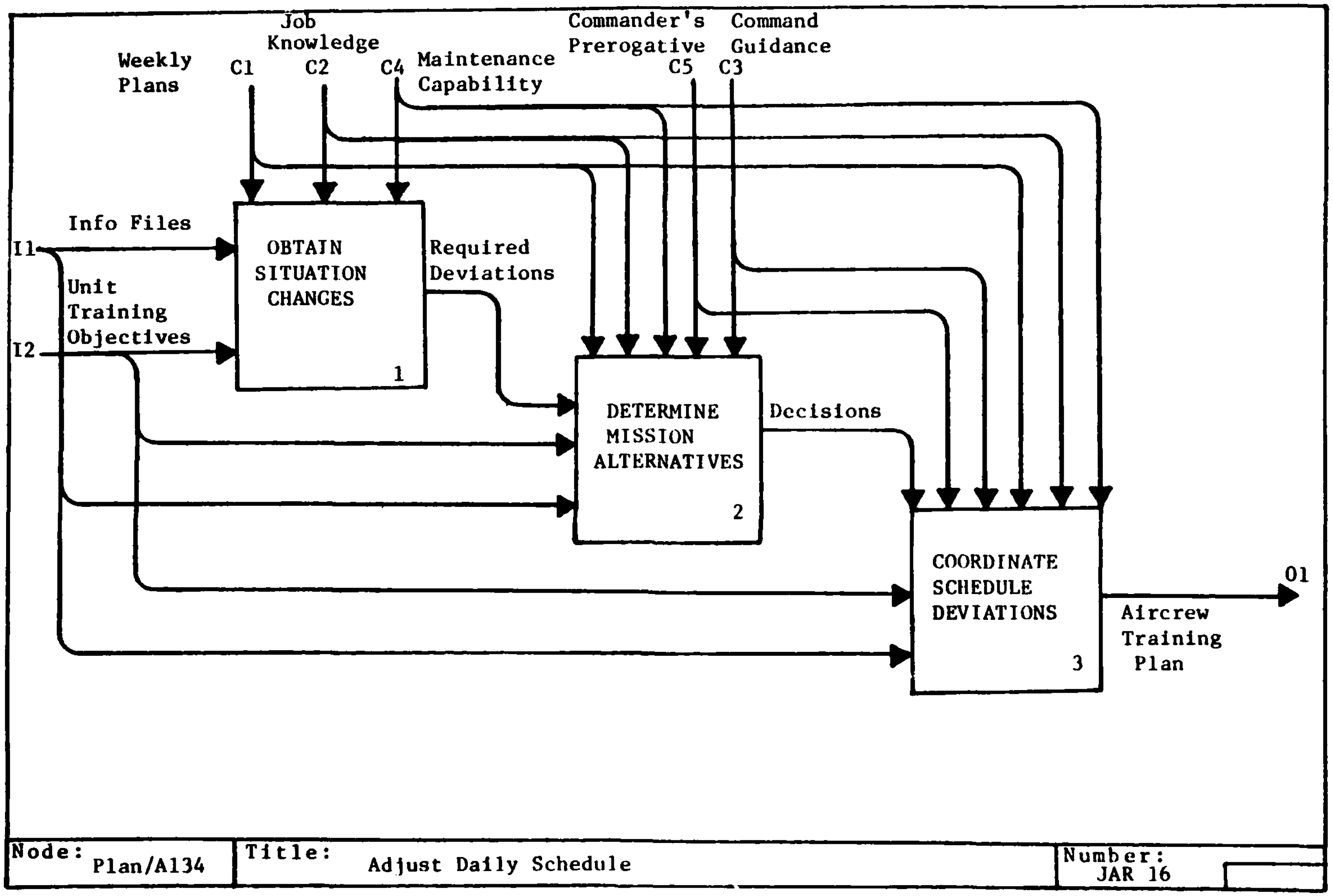

Fig 4.22. A134 Adjust Daily Schedule

Summary

$IDEF_0$ procedures used in this chapter result in the functional model for the planning process of unit B-52 activity. The model details the planning function using a hierarchical methodology originating from a "parent" box. Boxes representing functions and arrows symbolizing controls, inputs, and outputs supply the primary components of the detailed five level functional model. A single activity box "Assign Individuals By Name to Ground Alert Duty" gets further examination in Chapter 5 through the $IDEF_1$ information modeling technique.

Chapter 5

$IDEF_1$ INFORMATION MODEL

Introduction

The problems facing today's unit B-52 planners are highly complex and changing. Planning decisions result from incorporating the information derived from a dynamic environment with various managerial perceptions of the actual problem. Realizing that both the nature of scheduling decisions and individual planners vary, so will the nature of the information used to make a particular decision. Despite inherent situational and human differences, planners use some form of a model as a basis to gather information for analysis and possible future use when making a decision.

The individual charged with the majority of the original operational planning within a B-52 unit is the chief of the mission development branch. This individual usually devotes many hours to requesting, acquiring, and organizing numerous messages, documents, reports, and computer printouts from various sources as he/she prepares the unit training plans. As depicted in Chapter 4, several activities exist within the B-52 unit which require planning. This chapter presents a model detailing the information required to plan the assignment of qualified B-52 combat crew members to ground alert duty on the monthly operations final schedule.

PURPOSE: This effort develops an $IDEF_1$ information model detailing the necessary data required to assign individuals by name to B-52 ground alert duty on the monthly operations plan.

VIEWPOINT: The model development follows the perspective of a mission developer formulating a monthly operations plan within a B-52 unit.

Node:	Title: Strategic Objective	Number: JAR 17

Fig 5.1. $IDEF_1$ Strategic Objective

The activity box chosen for this $IDEF_1$ information model occurs on the sixth hierarchical level of the functional model. Figure 5.2 presents the node tree linking the general A-0 activity box to the specific function picked for analysis within these pages. As depicted by the node tree, the careful reader learns that the parent activity box requires alert assignment planning to occur at least once a month. One should remember that this chapter models only one of a myriad of functions within unit B-52 activity planning.

Description

A simple example for planning monthly alert duty assignments included within this chapter illustrates general $IDEF_1$ methodology for building an information model. The process begins with collecting the documents applicable to the organizational alert assignment procedures. Next, a completed series of entity-attribute based data collection forms leads to a graphic projection of the model orientated towards the stated purpose and viewpoint (see Figure 5.1). A generalized entity of the diagram results from the graphic projection. Also included within this effort to support the modeling methodology, an Entity-Relation-Attribute glossary provides recognition of key attributes.

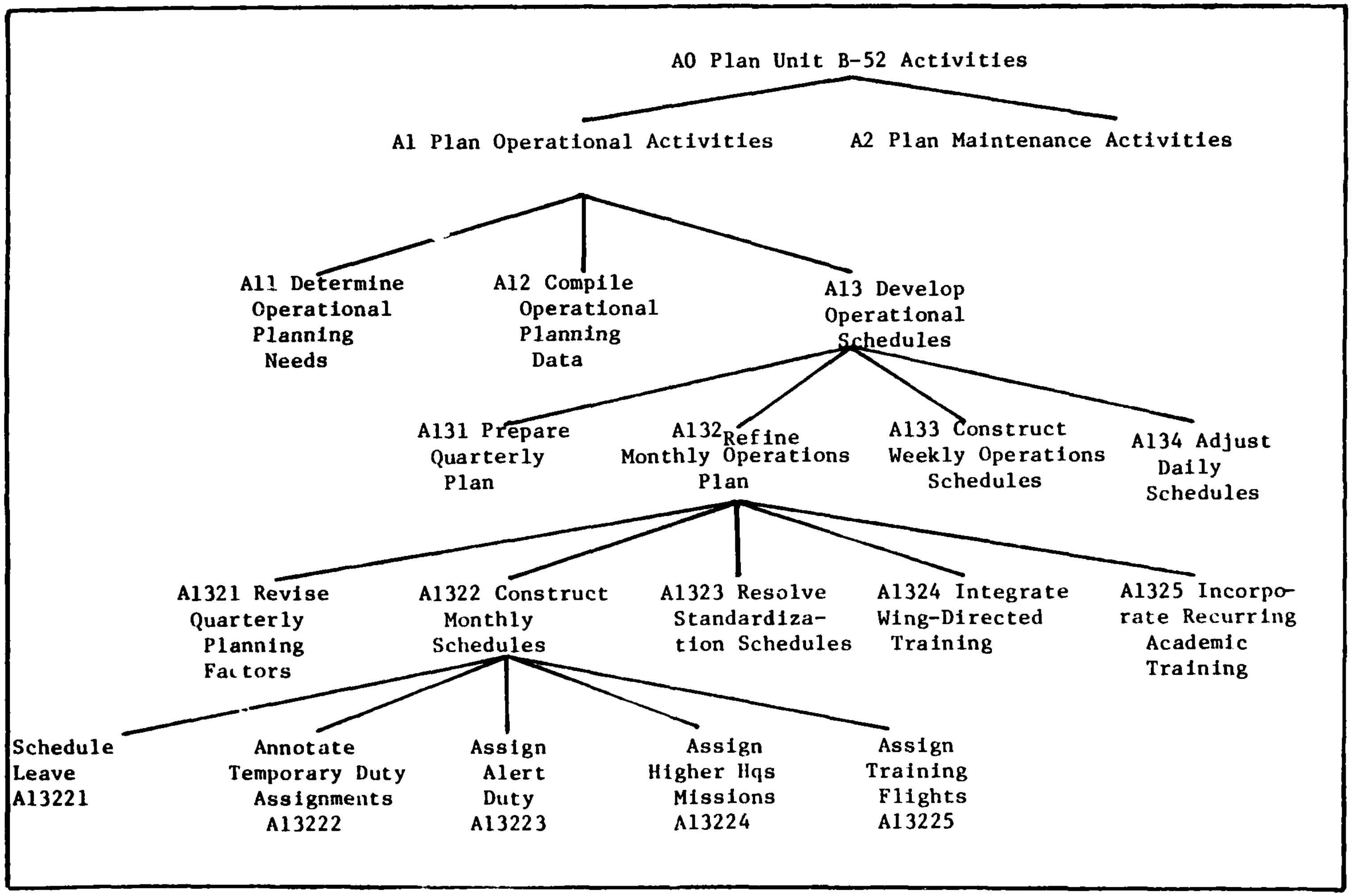

Fig 5.2. $IDEF_0$ Hierarchical Links to 'Assign Alert Duty' Node

Source Data Documents

Two primary documents used in the information model construction include the source material log and the source data list. The log associates a source material (SM) number with a name or description and material origin, as shown in Figure 5.3. The data list includes those factors which contribute to the overall information needed for the particular function being modeled. In addition to presenting each data name and source data (SD) number, the list contains a cross-reference to the source material number for tracing key elements throughout the model. Figure 5.4 depicts the source data list used to construct the model.

Activity Box Output

Prior to understanding what types of inputs or information an activity requires, the modeler must understand what desired output should result from the activity. The specific resultant desired from this process takes the form of a monthly plan assigning qualified crew members to continuously man the unit's ground alert commitment. Further, the plan reflects a minimization of alert crew/individual substitutions consistent with an equitable distribution of the alert duty workload described in current directives. Some problems exist for the planner because several controls govern the activity which in turn also affect the information required to effectively reach the desired output.

Source Material	Source Material Name/Description	Received From	Comments
SM 1	Combat Crew Capabil ties and Upgrade Minutes	Tactical Squadrons	
SM 2	Instructor Orders	Standardization Evaluation Division	Published as Required
SM 3	Form 8/Form Letter	Standardization Evaluation Division	
SM 4	Mission Accomplishment Reports	Flight Records	
SM 5	Quarterly Training Plan	Mission Development Branch	
SM 6	Leave Form Letters	Each Staff Unit and Tactical Sqdn	
SM 7	Certification Form Letters	Tactical Squadrons	
SM 8	Alert Assignment Sheet	Mission Development Branch	Local Form Design
SM 9	Squadron Notification	Tactical Squadrons	Verbal
Node: PO/X1	Title: Source Material Log		Number: JAR 18

Fig 5.3. $IDEF_1$ Source Material Log

Source Data ID No.	Source Data Name	Source Material Cross Reference	Comments
SD 1	Crew Number	SM 1, 5	
SD 2	Crew Position	SM 1, 5	
SD 3	Crewmember Name	SM 1, 3, 4, 5	
SD 4	Crewmember Number	SM 4	Assigned by Form 5 Personnel
SD 5	Crewmember Qualification	SM 3	
SD 6	Crewmember Currency	SM 4	Updated when Accomplished Computer batched
SD 7	Crewmember Readiness	SM 4	Updated when Accomplished Computer batched
SD 8	Instructor Crewmember	SM 1, 2	
SD 9	Evaluator Crewmember	SM 1	
SD 10	Crewmember Status Change	SM 1	
Node: PO/X2	Title: Source Data List		Number: JAR 19

Fig 5.4. $IDEF_1$ Source Data List

Source Data ID No.	Source Data Name	Source Material Cross Reference	Comments
SD 11	Crewmember Certifications	SM 7	
SD 12	Crewmember Leave	SM 6	
SD 13	Crewmember Temporary Duty (TDY)	SM 1	
SD 14	Crewmember Duty Not Including Alert (DNIA)	SM 1	
SD 15	Crewmember Holiday Alert	SM 5	
SD 16	Crewmember Alert Assignment	SM 8, 5	
SD 17	Crewmember Rank	SM 1, 2, 3, 5	
SD 18	Crewmember Unit	SM 1, 2, 3, 4, 5,6	
SD 19	Permanent Change of Station	SM 1	
SD 20	Security Clearance	SM 9	
Node: P0/X3	Title: Source Data List		Number: JAR 20

Fig 5.4. cont., $IDEF_1$ Source Data List

Requirement

Another factor affecting what information the activity requires for effective goal achievement involves control constraints. Planners ask the question, "What information do we need to comply with the command directives governing this activity?" The following requirements present a few constraint examples which necessitate the planner obtain or become aware of very specific bits of information prior to accomplishing the monthly alert scheduling process.

- Each B-52 wing shares responsibility for the alert concept by manning a required number of aircraft for day-to-day alert with qualified aircrew members. Only crewmembers who undergo a thorough study of the Emergency War Order procedures and certify their knowledge of designated war missions to the wing commander may be assigned to alert duty.

- The crew member must be qualified in the aircraft which means passing both ground and inflight evaluations measuring his ability to safely operate the weapon system. Under some circumstances an individual may be deemed unqualified after a standardization evaluation check ride. A unit commander might allow a crew member's assignment to alert duty if he is confident that the crew member can perform the war mission safely. In addition to being qualified, crew members must satisfy currency and readiness requirements as described in existing training directives.

- Mission developers may not assign an individual beyond the maximum crew tour length of seven consecutive days

(SACR 55-43, 1979:p.2-8). Another objective established by SACR 55-43, SAC Alert Procedures, states that mission developers plan the crew member's duty workweek averaged over a six-month period below a seventy-four hour maximum (1979: p.2-9). Alert duty for crew members assigned to evaluation tasks normally should not exceed sixty percent of that required by other crew members. The senior standardization evaluation crew members' alert duty requirements should not top fifty percent. Figure 5.6 presents the $IDEF_1$ definition for the requirement entity class.

Usually the bulk of the constraint or requirement information remains fairly static. Data elements concerning individual security clearances, unit mission checkouts, or certification don't change very often. For example, once an individual receives a security clearance, he/she retains that level until a new duty assignment requires a different access authorization or the individual does something to invalidate the clearance. Experienced unit planners for monthly activities generally rely upon their memory to help with the first iteration of assigning crew members to alert on the monthly plan. This static information receives review during the quarterly planning period. A monthly scheduler would use changes to this stable information base to evaluate the appropriateness of the alert lines as originally planned during the quarterly phase.

	Entity Class	Source Data ID No.		Entity Class	Source Data ID No.
Node No.	Name		Node No.	Name	
E 1	REQUIREMENT	SD 6			
E 2	RESOURCE	SD 2			
E 3	NON-AVAILABILITY	SD 13			

Node: P1/X1	Title: Entity Class Pool	Number: JAR 21

Fig 5.5. $IDEF_1$ Entity Class Pool

ENTITY CLASS NAME: REQUIREMENT

ENTITY CLASS LABEL: RQMT

ENTITY CLASS DEFINITION: All actions which must be completed prior to planning a resource to alert duty.

ENTITY CLASS SYNONYM(S): Control Constraint

Node: P1/E1	Title: Entity Class Definition: Requirement	Number: JAR 22

Fig 5.6. $IDEF_1$ Requirement Entity Class

Resource

The information required to identify resources consists of several attributes. Within military organizations the classic name, rank, and social security identification number serve to establish positive differentiation between individuals for most records. For the operations planner, additional data elements helpful in the construction of monthly plans include an individual's crew specialty, unit to which assigned, crew assignment plus several others. Figure 5.7 presents the $IDEF_1$ definition of the resource entity class. After determining the requirement and resource information, the mission developer considers the availability of resources to fulfill the requirements.

ENTITY CLASS NAME: RESOURCE

ENTITY CLASS LABEL: RES

ENTITY CLASS DEFINITION: Manpower, funds, facilities, and material required to accomplish planning B-52 operational personnel to ground alert duty.

ENTITY CLASS SYNONYM(S):

Node: P1/E2	Title: Entity Class Definition: Resource	Number: JAR 23

Fig 5.7. $IDEF_1$ Resource Entity Class

Non-Availability

Compared to requirement and resource information, non-availability data changes provide the majority of fluctuations in the information base. On a monthly basis, planning includes those known changes in resource availability to fill vacancies created on crews by such things as temporary duty, a crew change, or out of cycle leave. Non-availability entity class definition is presented in Figure 5.8.

ENTITY CLASS NAME: NON-AVAILABILITY

ENTITY CLASS LABEL: NON-AVAIL

ENTITY CLASS DEFINITION: All requirement and resource conditions which preclude their use in manning B-52 ground alert duty.

ENTITY CLASS SYNONYM(S)

Node: F1/E3	Title: Entity Class Definition: Non-Availability	Number: JAR 24

Fig 5.8. $IDEF_1$ Non-Availability Entity Class

Attribute Classes

Each entity has detailed informational subunits termed attribute classes. Attribute classes maintain at least one interface with each other for each particular entity. This section presents the data sheets for the three entity classes providing the backbone of this information model.

Entity Class Definition: Actions to be Completed

Attribute Class Name	REPT	ID #	Description/Role/Comment
Weapon System			B-52 Aircraft/Simulator
Security Clearance			
Emergency War Order			Studied and Briefed
Personnel Reliability Prg.			Nuclear Weapon Safety Program

Node: P1/E1D	Title: Entity Class: Requirement	Number: JAR 25

Fig 5.9. Information Model Data Sheet for Requirement Entity Class

ATTRIBUTE CLASS NAME: WEAPON SYSTEM

ATTRIBUTE CLASS LABEL: WEAP SYS

ATTRIBUTE CLASS DEFINITION: A composite of equipment, skills and techniques that together form an instrument of combat which, usually, but not necessarily, has an aerospace vehicle as its major operational element (McCann et al., 1981:741)

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A1	Title: Attribute Class Definition: Weapon System	Number: JAR 26

Fig 5.10. $IDEF_1$ Attribute Class Weapon System

ATTRIBUTE CLASS NAME: SECURITY CLEARANCE

ATTRIBUTE CLASS LABEL: SEC CLEAR

ATTRIBUTE CLASS DEFINITION: An investigation into an individual's past history to determine probably security risk in authorizing the individual access to classified material.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A2	Title: Attribute Class Definition: Security Clearance	Number: JAR 27

Fig 5.11. IDEF$_1$ Attribute Class Security Clearance

ATTRIBUTE CLASS NAME: EMERGENCY WAR ORDER

ATTRIBUTE CLASS LABEL: EWO

ATTRIBUTE CLASS DEFINITION: Procedures established to insure personnel reliability in performing the unit war mission.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A3	Title: Attribute Class Definition: *Emergency War Order*	Number: JAR 28

Fig 5.12. $IDEF_1$ Attribute Class Emergency War Order

ATTRIBUTE CLASS NAME: PERSONNEL RELIABILITY PROGRAM

ATTRIBUTE CLASS LABEL: PRP

ATTRIBUTE CLASS DEFINITION: A system of evaluations including medical, mental, and personal review to insure the reliability of personnel handling nuclear weapons.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A4	Title: Attribute Class Definition: Personnel Reliability Program	Number: JAR 29

Fig 5.13. $IDEF_1$ Attribute Class Personnel Reliability Program

Entity Class Definition: Manpower to Accomplish Alert Planning

Attribute Class Name	REPT	ID #	Description/Role/Comment
Name			
Rank			
Position			
Social Security #		1	
Unit			
Proficiency			
Crew Number		1	

Node: P1/E20 | Title: Entity Class: Resource | Number: JAR 30

Fig 5.14. Information Model Data Sheet for Resource Entity Class

ATTRIBUTE CLASS NAME: NAME

ATTRIBUTE CLASS LABEL: NAME

ATTRIBUTE CLASS DEFINITION: The combination of words by which an individual is known.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A5	Title: Attribute Class Definition: Name	Number: JAR 31

Fig 5.15. $IDEF_1$ Attribute Class Name

ATTRIBUTE CLASS NAME: RANK

ATTRIBUTE CLASS LABEL: RANK

ATTRIBUTE CLASS DEFINITION: The designation of authority levels within the military system.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A6	Title: Attribute Class Definition: Rank	Number: JAR 32

Fig 5.16. $IDEF_1$ Attribute Class Rank

ATTRIBUTE CLASS NAME: POSITION

ATTRIBUTE CLASS LABEL: POS

ATTRIBUTE CLASS DEFINITION: The designation of different primary tasks required for effective weapon systems operation.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A7	Title: Attribute Class Definition: Position	Number: JAR 33

Fig 5.17. $IDEF_1$ Attribute Class Position

ATTRIBUTE CLASS NAME: SOCIAL SECURITY NUMBER

ATTRIBUTE CLASS LABEL: SSAN

ATTRIBUTE CLASS DEFINITION: A unique nine digit number assigned to each individual wage earner.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A8	Title: Attribute Class Definition: Social Security Number	Number: JAR 34

Fig 5.18. $IDEF_1$ Attribute Class Social Security Number

ATTRIBUTE CLASS NAME: UNIT

ATTRIBUTE CLASS LABEL: UNIT

ATTRIBUTE CLASS DEFINITION: The specific sub-organizations within a bombardment wing.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A9	Title: Attribute Class Definition: Unit	Number: JAR 35

Fig 5.19. $IDEF_1$ Attribute Class Unit

ATTRIBUTE CLASS NAME: PROFICIENCY

ATTRIBUTE CLASS LABEL: PROFICIENT

ATTRIBUTE CLASS DEFINITION: An individual who has successfully completed upgrade training for his crew position. Evaluation criteria include a high degree of job expertise coupled with an ability to train other individuals of the same crew specialty.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A10	Title: Attribute Class Definition: Proficiency	Number: JAR 36

Fig 5.20. $IDEF_1$ Attribute Class Proficiency

ATTRIBUTE CLASS NAME: CREW NUMBER

ATTRIBUTE CLASS LABEL: CREW #

ATTRIBUTE CLASS DEFINITION: A group composed of the proper number of personnel possessing the required Air Force Service Codes and duty titles applicable to the aircraft. Crews are designated by the following combinations of letter and number

(a) Prefix

- "N" Non-Mission Ready Crew
- "R" Ready Crew
- "E" Senior Crew
- "S" Select Crew

(b) Serial Number: Crew numbers range from 01 to 99 within each wing.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A11	Title: Attribute Class Definition: Crew Number	Number: JAR 37

Fig 5.21. $IDEF_1$ Attribute Class Crew Number

Entity Class
Definition: Conditions Which Preclude Resource Use

Attribute Class Name	REPT	ID #	Definition/Role/Comment
Alert			
Combat Crew Rest and Recuperation			
Temporary Duty			
Permanent Change of Station			
Currency			
Readiness			
Special			
Medical			
Leave			

Node: P1/E30	Title: Entity Class: Non-Availability	Number: JAR 38

Fig 5.22. Information Model Data Sheet for Non-Availability Entity Class

ATTRIBUTE CLASS NAME: ALERT

ATTRIBUTE CLASS LABEL: ALERT

ATTRIBUTE CLASS DEFINITION: Present or planned alert duty assignment. Individual already assigned may fulfill an aircrew position for one consecutive seven-day tour, but must be allowed Combat Crew Rest and Recuperation prior to returning to alert.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A12	Title: Attribute Class Definition: Alert	Number: JAR 39

Fig 5.23. $IDEF_1$ Attribute Class Alert

ATTRIBUTE CLASS NAME: COMBAT CREW REST AND RECUPERATION

ATTRIBUTE CLASS LABEL: CCRR

ATTRIBUTE CLASS DEFINITION: The period of time authorized to personnel for personal activity equal to one-half the amount spent on alert duty.

ATTRIBUTE CLASS SYNONYM(S):

Node: P 1/A13	Title: Attribute Class Definition: Combat Crew Rest and Recuperation	Number: JAR 40

Fig 5.24. $IDEF_1$ Attribute Class Combat Crew Rest and Recuperation

ATTRIBUTE CLASS NAME: TEMPORARY DUTY

ATTRIBUTE CLASS LABEL: TEMP DTY

ATTRIBUTE CLASS DEFINITION: Assignment to duty away from home station for a period of less than 180 consecutive days.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A14	Title: Attribute Class Definition: Temporary Duty	Number: JAR 41

Fig 5.25. $IDEF_1$ Attribute Class Temporary Duty

ATTRIBUTE CLASS NAME: PERMANENT CHANGE OF STATION

ATTRIBUTE CLASS LABEL: PCS

ATTRIBUTE CLASS DEFINITION: The reassignment of personnel to another duty station for longer than 180 days.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A15	Title: Attribute Class Definition: Permanent Change of Station	Number: JAR 42

Fig 5.26. $IDEF_1$ Attribute Class Permanent Change of Station

ATTRIBUTE CLASS NAME: CURRENCY

ATTRIBUTE CLASS LABEL: CURRENT

ATTRIBUTE CLASS DEFINITION: The minimum accomplishment frequency for selected training events by an individual and still be considered capable of performing it safely. Designated training events that must be included in the requalification of an individual who has not flown for an extended period.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A16	Title: Attribute Class Definition: Currency	Number: JAR 43

Fig 5.27. $IDEF_1$ Attribute Class Currency

ATTRIBUTE CLASS NAME: READINESS

ATTRIBUTE CLASS LABEL: READY

ATTRIBUTE CLASS DEFINITION: Those events considered critical to the success of the unit mission and must be accomplished at regular intervals for individuals to be assigned to alert duty.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A17	Title: Attribute Class Definition: Readiness	Number: JAR 44

Fig 5.28. $IDEF_1$ Attribute Class Readiness

ATTRIBUTE CLASS NAME: SPECIAL

ATTRIBUTE CLASS LABEL: SPEC

ATTRIBUTE CLASS DEFINITION: Those additional non-recurring requirements which could affect an individual's availability to perform alert duty.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A18	Title: Attribute Class Definition: Special	Number: JAR 45

Fig 5.29. $IDEF_1$ Attribute Class Special

ATTRIBUTE CLASS NAME: MEDICAL

ATTRIBUTE CLASS LABEL: MED

ATTRIBUTE CLASS DEFINITION: A personal condition which requires that an individual not be assigned to alert duty.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A19	Title: Attribute Class Definition: Medical	Number: JAR 46

Fig 5.30. $IDEF_1$ Attribute Class Medical

ATTRIBUTE CLASS NAME: LEAVE

ATTRIBUTE CLASS LABEL: LEAVE

ATTRIBUTE CLASS DEFINITION: The amount of available time an individual is authorized for vacation or other personal activities. Accumulates at a rate of two and one-half days per month.

ATTRIBUTE CLASS SYNONYM(S):

Node: P1/A20	Title: Attribute Class Definition: Leave	Number: JAR 47

Fig 5.31. $IDEF_1$ Attribute Class Leave

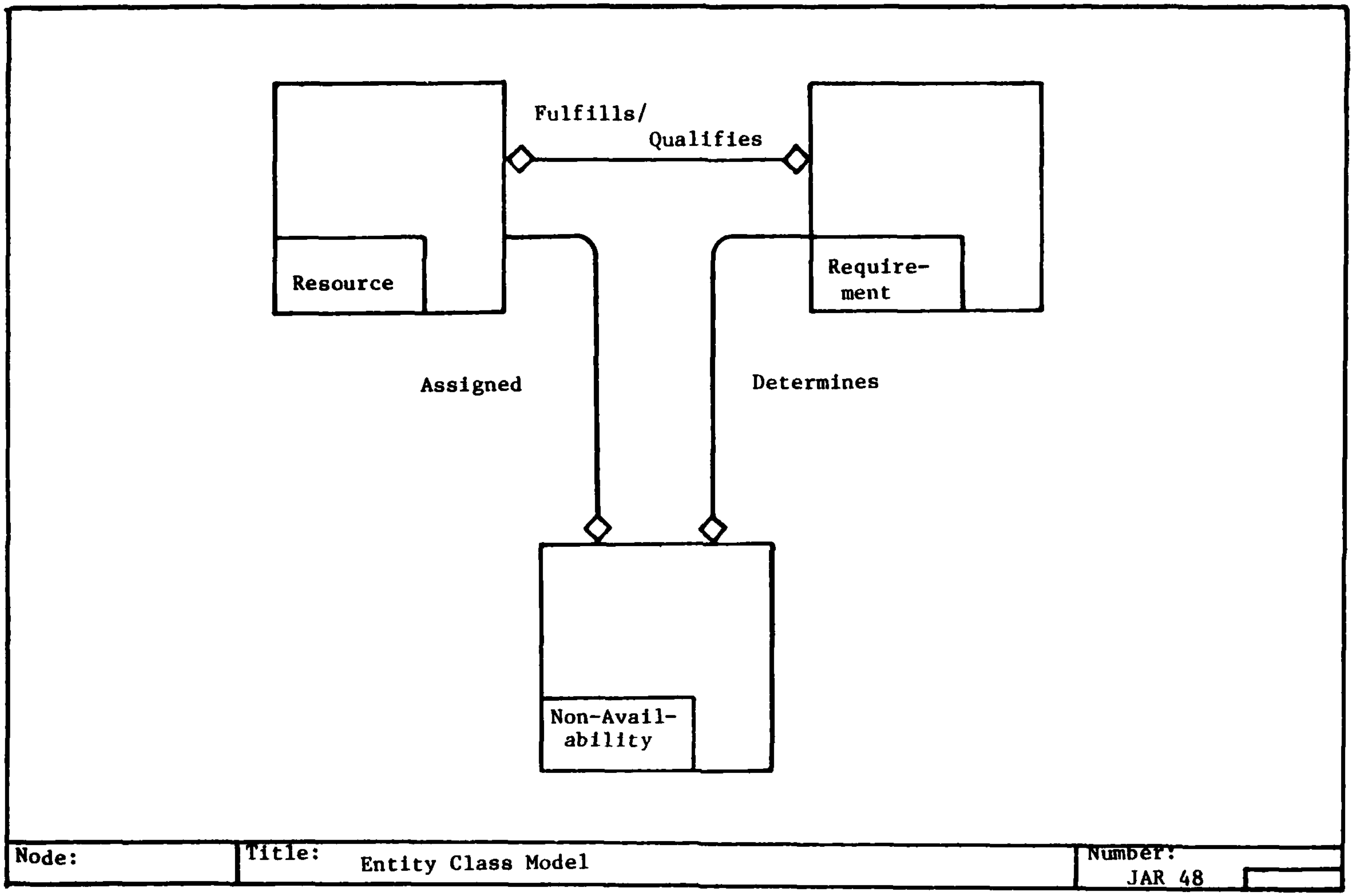

Fig 5.32. $IDEF_1$ Information Model

Summary

$IDEF_1$ methodology serves as the basis to build a simple information model for the functional aspects of assigning B-52 crew members to ground alert duty. A series of logs and forms serve to organize the informational requirements of the particular decisions under scrutiny within this effort. A general grouping termed entity classes forms the model's framework. The basic hierarchical level within the $IDEF_1$ methodology begins with groups of entity classes, each possessing numerous attribute classes.

The information model built describes resources fulfilling requirements which qualify resources for a task. Requirements also determine the non-availability criteria for usable resources. Other resource information provides assigned non-availability to the alert duty planning for a particular period. The information model is just a small step toward the construction of a dynamic model. Through the application of $IDEF_0$ and $IDEF_1$ procedures and methodology, the authors consider the SAC B-52 aircrew scheduling problem solvable.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This research effort started with a general discussion of scheduling It defined scheduling as a process which coordinates and adjusts activities, resources and facilities. From this general view, the authors quickly narrow-in on the aircraft and aircrew scheduling process within SAC B-52 wings. This scheduling process is also defined in rather general terms. Aircraft and aircrew scheduling in SAC B-52 wings involves many man-hours of attending conferences and meetings; sorting through program documents, higher headquarters messages, various forms, and computer printouts; and making telephone calls to compile planning data. Once the data compilation is complete, it is manually posted to a master programming board. The schedulers then coordinate and adjust taskings; flight and ground training events, and planned and unplanned aircraft maintenance (the activities); crew members, maintenance personnel, aircraft, equipment, and allocated flying hours (the resources); and buildings, hangars, and classrooms (the facilities) in an effort to achieve an optimal combination which effectively meets the unit's mission objectives. These decisions are made within a framework of formalized guidance and informal unit policies. However, unpredictable factors usually arise which result in the need to partially or even completely rework the schedule. At this point, the scheduler adjusts the schedule to "crisis manage" the unforeseen event. The art of "satisficing" is practiced because the schedule changes made by the scheduler are often done without the benefit of the overall perspective maintained during the original schedule formulation. There have been numerous approaches toward correcting the aircraft and aircrew scheduling problem, not only in SAC but also in other commands.

Some of these efforts attempted to conceptualize the scheduling system by drawing visual models which depicted the interactions and interfaces between various aspects of the scheduling system. A 1960 Rand Corporation study by Levine was one of the first articles investigating conflicting demands for limited resources. Theses written by four students at the Air Command and Staff College addressed the general subject of SAC aircrew scheduling during the mid 1960's (Bott, 1965; Gehrke, 1964; Stewart, 1965; and York, 1964). Then in 1970, Burkepile's research presented a consolidated description and analysis of the major requirements and scheduling function constraints. In the early and mid 1970's, SAC contracted the Rand Corporation to investigate ways of increasing resource allocation efficiency by improving aircraft and aircrew scheduling. A major contribution of this effort is the depiction of the complexity of the system and its resource allocation problem. A 1975 study by Gibson suggests moving the aircraft and aircrew scheduling functions from under the maintenance and operations commanders, respectively, to a consolidated scheduling function directly responsible to the wing commander. A recent research effort by Barnidge and Cioli (1978) uses System Dynamics methodology in developing a hypothesized structure of the scheduling process. Through this technique the effect of one occurrence upon the rest of the system is modeled by the use of causal-loop diagrams. Pluses and minuses are used to indicate the influence of one action on another. Eventually the modeling approach leads to the determination of rates and flows which lend themselves to equation formulation. Theoretically, at this point the system can be modeled through computerization.

The recommendations in the research inevitably suggest computerizing some aspects of the manual aircraft and aircrew scheduling process or developing a system to produce schedules. There have been several successful attempts in the Air Force toward computerizing the scheduling function. One such effort occurred at Whiteman AFB for the SAC minuteman combat crew scheduling system (Bush, 1978; and Kerr, 1982). Another successful attempt computerized the flying training for a tactical fighter squadron (Egge, 1978). A third effort (Pease, 1978) computerizes the scheduling process by dividing it into planning and scheduling modules for the wing. In contrast, there is one notable effort that failed in its attempt to computerize the scheduling process. A 1974 Berman study for the Rand Corporation suggests the parallel development of an aircraft and aircrew decision-oriented scheduling system for all of SAC. It tries to be a panacea for the scheduling problem on a command-wide basis. What it fails to account for is that each wing is a system in its own right. A current SAC effort at aiding decision-makers is the incorporation of microcomputers and optimal mark scanners into the wing scheduling shops as part of the Air Force Operations Resource Management System (Mitchell, 1981). However, this scheduling effort also appears doomed for failure because it does not account for individual wing differences and decision-maker personalities.

An approach that does consider organization and personality differences when constructing a computer-aided decision-making system is the concept of Decision Support Systems (DSS). It implies the use of computers to assist managers in the decision process where tasks are semistructured, support managerial judgment, and improve decision-making effectiveness (Keen and Morton, 1978:1). A DSS is most applicable in situations where a large data base exists, the data needs to be manipulated to arrive at a solution, some time pressure is involved, and the need for judgment when selecting an alternative (Keen and Morton, 1978:96-97). The first step is to build a descriptive model of the system (the way it is) and then construct a normative model (the way it ought to be). Both of these models are developed through a joint effort by the users of the system and the system designer. At this point the new system is incrementally implemented by using the cognitive style paradigm (Keen and Morton, 1978:175-177). This way the implementation stage is an iterative process which moves the system from its descriptive model to its normative model. Successful completion of the DSS implementation depends on a prior definition of improvement, progress monitoring towards the goal, and a review process which determines when the system is complete (Keen and Morton, 1978:213).

A key part of any DSS is its data base and the management of that data base. This involves decisions on hardware and software configuration; data storage, access, and retrieval; and data definition and security. The hardware and software decisions will vary from system to system. These decisions will depend on the uniqueness of the system and its peculiarities, the current system's configuration, hardware and software availability, and cost. Data storage, access, and retrieval also vary from system to system, and they depend on the hardware and software decisions. De and Sen recommend the data be stored in modules which support the decision under consideration (1981). This makes data access and retrieval simpler and faster. Finally, the problems of data definition and security must be addressed. Data definition involves the defining and coding of the data for the users of the system. In this manner everyone attaches the same meaning to a particular piece of information and duplicate meanings and codes are eliminated.

There have been several areas where the concept of

DSS has been successfully applied. Clearly, aircraft and aircrew scheduling contain the aforementioned characteristics which lend to DSS application. The current decision then is to select a modeling methodology that best portrays this scheduling function and its information requirements.

The modeling approach selected was developed by the Materials Laboratory of the Air Force Wright Aeronautical Laboratories in cooperation with SofTech Incorporated. The technique was created for the Air Force's Integrated Computer-Aided Manufacturing (ICAM) Program. The program developed an ICAM Definition (IDEF) method which addresses various manufacturing characteristics (Ross et al., 1981:3). IDEF involves three modeling methodologies which graphically portray the system. Only the first two methodologies are presented in this research.

The first modeling methodology, $IDEF_0$,

> is used to produce a <u>function</u> model which is a structured representation of the functions of a manufacturing system or environment, and of the information and objects which interrelate those functions [Ross et al., 1981:3].

It consists of boxes representing activities and arrows representing the inputs, controls, outputs, and mechanisms affecting the activity. Each activity is broken down into its subfunctions until the desired level of detail is reached. Once the function model is constructed the next step is to develop the information model.

The second modeling methodology, $IDEF_1$, "is used to produce an <u>information</u> model which represents the structure of information needed to support the functions of a manufacturing system or environment [Jones et al., 1981:3]." This model consists of Entity and Attribute Diagrams and their supporting documentation. The diagrams consist of boxes representing entity classes and attribute classes and arrows depicting their relationships. The documentation supporting the diagrams consist of source material logs, source data lists, a dictionary, and a glossary. "At this point, the information model is in a form which will facilitate basic translation into a data base management system [Jones et al., 1981:195]."

Because of the success of IDEF modeling methodology to the manufacturing process and other related areas, the authors believe it appropriate to apply the technique to aircraft and aircrew scheduling. To avoid the difficulties encountered by previous modelers, and to apply DSS concepts and the successes of other modelers, the authors chose to model the B-52 aircrew scheduling process for the 28th Bombardment Wing at Ellsworth AFB, South Dakota. A parallel thesis (Hackett and Pennartz, 1982) models the B-52 aircraft maintenance scheduling process for the same wing.

Conclusions

The overall objective of this research is to construct a model of the B-52 aircrew scheduling function at Ellsworth AFB. It is believed this model can eventually be used to devise a complete computer-aided decision support system for this process. Because of the breadth of this effort and time constraints involved, the overall objective was narrowed in scope to building a function model of the unit B-52 aircrew scheduling process and then constructing an informational model for one of the myriad of decisions within the scheduling process. Specifically, an informational model is built for the monthly decision to assign individuals by name to ground alert duty.

The first objective of this research is to construct a functional model of the B-52 aircrew flight and ground training events scheduling process for the 28th Bombardment Wing. The purpose is to determine this scheduling process' functional elements and informational relationships. The process is modeled using $IDEF_0$ methodology. First, the process is broken down into four broad functional areas--determining unit B-52 mission objectives, planning unit B-52 activities, implementing the unit B-52 plan, and evaluating the effectiveness of the unit B-52 plan. At this point the research focused on planning unit B-52 activities. This functional area was broken down into planning operational activities and planning maintenance activities. While this research develops the planning of operational activities, a parallel thesis (Hackett and Pennartz, 1982) concentrates on the planning of maintenance activities. Within planning operational activities, three more functional areas are defined--determine operational planning needs, compile operational planning data, and develop operational schedules. This hierarchical breakout continues through two more levels of activity for these last three functional areas.

The informational relationships for planning unit B-52 activities are also determined. In general the planning process is controlled by higher headquarters guidance and the prerogatives of the wing commander. The process transforms unit mission objectives and other informational inputs into an aircrew training plan and a unit maintenance plan. In the planning of aircrew activities, unit training objectives and general informational inputs are transformed into an aircrew training plan and planned operational requirements. This process is constrained by not only higher headquarters guidance and wing commander prerogatives, but also by the capabilities of the maintenance function. The planning of maintenance activities takes the unit maintenance objectives and other general information, and transforms them into a unit maintenance plan and maintenance capability. At the same time this function is controlled by the guidance of higher authority levels, the unit commander's prerogatives, and the planned operational requirements. Within the planning of aircrew activities, all three previously mentioned functions transform general informational inputs such as unit training objectives into a desired output. Determining operational planning needs transforms the inputs into job knowledge by the studying of higher headquarters guidance. In compiling operational planning data, the inputs are transformed into various information files. This process is controlled by not only the guidance established by higher headquarters, but also maintenance capability and job knowledge. Finally, operational training plans are developed by transforming the inputs into planned operational requirements and an aircrew training plan. This function is constrained by higher headquarters guidance, wing commander prerogatives, job knowledge, maintenance capability, and planned operational requirements. This input-control-output process is developed for the next two lower hierarchical levels formulated in the functional model.

The second objective of this reseatch is to construct an informational model for the monthly assignment of individuals by name to B-52 ground alert duty at the 28th Bombardment Wing. The purpose here is to determine the informational needs in making the decision. This decision-making process was modeled using $IDEF_1$ methodology. The informational entities, attributes, and relationships for this decision are identified and grouped into their respective classes. The entity classes and their attributes are defined within the context of the modeled decision. A glossary which includes a definition, label, and synonym for each entity class and their attributes is provided. Also a source material log and source data list with cross references are presented for this decision. There are three entity classes identified for the monthly decision to assign a particular individual to ground alert duty. They are resources, requirements, and non-availability. The relationships between these three entity classes in the informational model are: resources fulfilling requirements which qualify resources for the task, requirements determining the non-availability criteria for the resources, and resources being assigned either available or non-available for the task.

Through the IDEF modeling methodologies, the authors were able to determine the necessary functions and their information and object relationships for planning unit B-52 activity. And within this context they were able to establish the information needs for the monthly decision to assign individuals by name to ground alert duty. All of this was accomplished within the broader system of B-52 aircrew flight and ground training events scheduling for the 28th Bombardment Wing. Because of its prior successes and the success the authors had in using IDEF modeling methodologies, it appears that this technique may be applicable in other areas in the Air Force, Department of Defense, other governmental agencies, and industry. Anywhere a need exists to fully understand the activities, their informational relationships, and their informational needs, it appears that IDEF modeling methodology may be useful. However, it should not be viewed as a panacea for everything--capable of modeling, solving, and improving any problem.

Recommendations

The modeling process started here is far from being complete. In fact it has only just begun. There are several steps which must be accomplished before the SAC B-52 aircrew flight and ground training events scheduling process for the 28th Bombardment Wing is transformed into a total computer-aided decision support system. Therefore, the authors recommend the following:

1. Using $IDEF_1$ methodology, develop the information models for the other decisions under the function of planning unit B-52 activities. Some fruitful areas to explore are the quarterly decisions involving aircrew leaves/alerts and individual/crew temporary duty; monthly decisions involving individual leaves, physicals, qualification flights, physiological training, and aircrew ground events training; weekly decisions for assigning aircrews/individuals to training flights and individuals to ground events training; and daily decisions involving crew member substitutions on training flights, alert, and temporary duty.

2. Once some of these information models are built, link two or three of the closely related ones together into one model. This can assist in tracing key informational ties between decisions, eliminate data redundancy, and show how one decision affects another. Through this building block approach one will eventually be able to see the rippling effect of one decision on the entire system.

3. The information model for the monthly decision of assigning individuals by name to ground alert duty should be translated into a data base management system. As the other information models are developed they should also be translated

into a data base management system. To avoid not only data redundancy, but also the need for a large storage capacity, the information model being translated should be matched with those already translated to identify key informational links.

4. Using $IDEF_2$ methodology, "produce a dynamics model which represents the time varying behavior of functions, information and resources [Miner et al., 1981:3]" for the planning of unit B-52 activity and its environment. The purpose of this model is to describe the time-varying behavior of the system in an effort to analyze its performance measurements via computer simulation (Miner et al., 1981:11). This model will significantly aid decision-makers when selecting among alternative courses of action. They will be able to see the effect of various decisions on the complete system before the decision is actually made.

5. Using IDEF methodology, construct a function, information, and dynamics model for the other three A-0 levels of activity (i.e., develop unit B-52 mission objectives, implement the unit B-52 plan, and evaluate the unit B-52 plan). Just as in the area of plan unit B-52 activity, the models can assist the planners and decision-makers within these three areas. Alternative mission objectives can be studied, plan implementation can be facilitated with alternative courses of action analyzed, and evaluation of the plan and its implementation with respect to mission objectives can be easily determined.

6. Determine the links between all four A-0

levels of activity for this wing's B-52 aircrew scheduling process. Basically this will involve determining the output for each A-0 level of activity and its input link, if any, to the other three levels of activity. Eventually the entire system will be modeled and the effect of any one decision on the overall system can be determined (i.e., How does a change in a mission objective affect plan development, implementation, or evaluation? How does plan evaluation affect its development and implementation? etc.).

7. Determine hardware and software requirements, system configuration, and cost. Several tough decisions are made at this point. It must be determined whether to use one or several microcomputers, or one large central computer; how the data is to be stored, accessed, updated, and retrieved; visual presentation of output; how and what data is to be collected; and benefit/cost tradeoffs of the system, its capacity, and the information it stores and collects.

8. Determine the training requirements for the scheduling personnel. What type of experience or background is needed? What are the on-the-job training requirements? What course material needs to be added in technical training schools? How to administer career development course material through the Extension Course Institute? These and other training questions need to be answered.

9. As each information model is constructed, they should be linked to previous information models in modular form, the new data base defined and developed, and the new

system implemented. This allows the users to get hands-on experience faster than if the complete system was defined before it was implemented. As problems within the system arise, they can be identified and corrected easier. And the time required to implement the system will be facilitated.

10. As each step in developing the total decision support system is taken, the problems encountered and corrective action taken needs to be documented. This way they can be used to reconstruct what was done, avoid similar mistakes, and unproductive areas will not be explored again.

Once this project is complete, the 28th Bombardment Wing at Ellsworth AFB, South Dakota, will have a complete computer-aided decision support system that assists bomb squadron managers in the decision process, supports managerial judgment, and improves decision-making effectiveness. Command attention can then focus on the adoption of successful procedures to other units and differing missions.

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

Alavi, Maryam, and John C. Henderson. "An Evolutionary Strategy for Implementing a Decision Support System," Management Science, November 1981, pp. 1309-1323.

Alter, S. "A Taxonomy of Decision Support Systems," Sloan Management Review, Fall 1977, pp. 39-56.

Balachandran, Bala V., and Andris A. Zoltners. "Interactive Audit - Staff Scheduling Decision Support System," The Accounting Review, October 1981, pp. 809-812.

Barnidge, Captain Leroy, Jr., USAF, and Captain Brian H. Cioli, USAF. "The Wing Level Scheduling Process: A Systems Approach." Unpublished master's thesis. LSSR 15-78B, AFIT/LS, Wright-Patterson AFB OH, September 1978. AD A060449.

Berman, Morton B. Improving SAC Aircrew and Aircraft Scheduling to Increase Resource Effectiveness. Rand Document R-1435-PR, Santa Monica CA, July 1974. AD 787206.

________. Scheduling Aircrews and Aircraft: Problems of Resource Allocations in the Strategic Air Command. Rand Document R-1610-PR, Santa Monica CA, January 1975. AD A011613.

Bonczek, Robert H., Clyde W. Holsapple, and Andrew B. Whinston. "Computer-Based Support of Organizational Decision Making," Decision Sciences, April 1979, pp. 268-291.

________, Clyde W. Holsapple, and Andrew B. Whinston. "The Evolving Roles of Models in Decision Support Systems," Decision Sciences, April 1980, pp. 337-356.

________, Clyde W. Holsapple, and Andrew B. Whinston. "Future Directions for Decision Support." Unpublished technical report, unnumbered, Purdue University, West Lafayette IN, June 1980. AD A087355.

Bott, Major Donald H., USAF. "An Analysis of the Use of Human Relations in the Management of the SAC Combat Crew." Unpublished master's thesis. Air Command and Staff College, Maxwell AFB AL, June 1965.

Boyd, Major James A., Jr., USAF, and Major Gary J. Toy, USAF. "An Evaluation of the Use of the Logistics Composite Model to Measure the Effectiveness of Aircraft Flying Schedules." Unpublished master's thesis. SLSR 8-75B, AFIT/SL, Wright-Patterson AFB OH, August 1975. AD A016267.

Burkepile, Captain Dick L., USAF. "An Analysis of the Aircrew Scheduling Function in a Strategic Air Command Bombardment Wing." Unpublished master's thesis. GSM/SM/70-02, AFIT/SE, Wright-Patterson AFB OH, November 1970.

Bush, First Lieutenant Michael D., USAF. "Automated Missile Operations Management System." Unpublished research report, unnumbered, 351st Strategic Missile Wing, Whiteman AFB MO, 8 June 1978.

Chase, Richard B., and Nicholas J. Aquilano. Production and Operations Management: A Life Cycle Approach. Homewood IL: Richard D. Irwin, Inc., 1981.

Clemons, Eric K. "Data Base Design for Decision Support." Unpublished research report, No. 80-10-02, University of Pennsylvania, Philadelphia PA, October 1980. AD A093442.

Cohen, I.K. Aircraft Planned Inspection Policies: A Briefing. Rand Document R-1025-PR, Santa Monica CA, June 1972.

________, E.V. Denardo, and P.J. Kiviat. Integrating Base Maintenance Management By Unifying Its Information Systems in Manual and Computer-Assisted Environments. Rand Document RM-4849-PR, Santa Monica CA, June 1966.

De, Prabuddha, and Arun Sen. "Logical Data Base Design in Decision," Journal of Systems Management, May 1981, pp. 28-33.

Egge, Major Geoffrey A., USAF. "Computer Scheduling in a Tactical Fighter Squadron." Unpublished research report, No. 0660-78, Air Command and Staff College, Maxwell AFB AL, 1978. AD B029873.

Ewell, Ralph, and Chris Roach. Scheduled Maintenance Policies for the F-4 Aircraft: Result of the Maintenance Posture Improvement Program. Rand Document R-1942-PR, Santa Monica CA, 1976.

Fallon, Richard. Rule-Based Modeling as an Analysis Tool: Implications for Resource Allocation Within the Strategic Air Command. Rand Document N-1489-AF, Santa Monica CA, April 1980.

Forrester, Jay W. Industrial Dynamics. Cambridge MA: MIT Press, 1961.

Gehrke, Major Edward F., USAF. "Crew Scheduling in B-47 Bombardment Wings." Unpublished research report, unnumbered, Air Command and Staff College, Maxwell AFB AL, June 1964.

Gibson, Colonel George H., Jr., USAF. "Consolidated Aircrew and Aircraft Scheduling." Unpublished research report, No. 5604, Air War College, Maxwell AFB AL, 1975. AD B003937.

Goodman, Michael R. Study Notes in System Dynamics. Cambridge MA: Wright-Allen Press, Inc., 1974.

Hackett, First Lieutenant Stephen B., USAF, and Captain Sam E. Pennartz, USAF. "Decision Support Systems: An Approach to Aircraft Maintenance Scheduling in the Strategic Air Command." Unpublished master's thesis. LSSR 42-82, AFIT/LS, Wright-Patterson AFB OH, September 1982.

Jones, Reuben S. "Integrated Computer-Aided Manufacturing (ICAM) Architecture Part II, Volume V, Information Modeling Manual ($IDEF_1$)." Unpublished technical report, No. AFWAL-TR-81-4023, Vol. V. SofTech, Inc., Waltham MA, June 1981. AD B062458L.

Keen, Peter G.W. "Decision Support Systems: Translating Analytic Techniques Into Useful Tools," Sloan Management Review, September 1980, pp. 33-44.

________ and Michael S. Scott Morton. Decision Support Systems: An Organizational Perspective. Reading MA: Addison-Wesley Publishing Company, 1978.

Kerr, Captain Robert, USAF. Chief, Missile Operations Training Division, 351st Strategic Missile Wing, Whiteman AFB MO. Telephone interview. 2 April 1982.

Kiviat, P.J. Computer-Assisted Maintenance Planning. Rand Document RM-4563-PR, Santa Monica CA, July 1965.

Levine, R.A. Organizational Support of B-52 Alert. Rand Document RM-2511, Santa Monica CA, January 1960. LD 06921.

McCann, Colonel John A., USAF (Ret.), and others, eds. "Compendium of Authenticated Systems and Logistics Terms, Definitions and Acronyms." Unpublished Technical Report, AU-AFIT-LS-3-81, Wright-Patterson AFB OH, April 1981.

McElmoyle, Lieutenant Robert Wilson, USCG. "The Development of the Informational Data Base Requirements for a Reserve Training Management Decision Support System." Unpublished master's thesis. Naval Postgraduate School, Monterey CA, March 1980. AD A089304.

Miller, L.W. VIMCOS II: A Workload Control Simulation Model for Exploring Man-Machine Roles in Decision-Making. Rand Document R-1094-PR, Santa Monica CA, June 1973.

________, R.J. Kaplan, and W. Edwards. Judge: A Value Judgement-Based Tactical Command System. Rand Document RM-5147-PR, Santa Monica CA, March 1967.

Miner, Robin J., and others. "Integrated Computer-Aided Manufacturing (ICAM) Architecture Part II, Volume VI, Dynamics Modeling Manual ($IDEF_2$)." Unpublished technical report, No. AFWA-TR-81-4023, SofTech, Inc., Waltham MA, June 1981. AD B062459.

Mitchell, Major Will D., USAF. "Automatic Scheduling Model." Unpublished report, unnumbered, Operations Systems Management Division, Headquarters Strategic Air Command, Offutt AFB NE, 15 April 1981.

________. "On Scheduling. . . ." Unpublished report, unnumbered, Operations Systems Management Division, Headquarters Strategic Air Command, Offutt AFB NE, 10 December 1980.

________. Operations Systems Management Division, Headquarters Strategic Air Command, Offutt AFB NE. Telephone interview. 1 September 1981.

Morton, Michael S. Scott. Management Decision Systems. Boston MA: Harvard University Press, 1971.

Pearl, Judea, Antonio Leal, and Joseph Saleh. "GODDESS: A Goal-Directed Decision Structuring System." Unpublished Technical report, No. UCLA-ENG-CSL-8034, University of California, Los Angeles, Los Angeles CA, June 1980. AD A094406.

Pease, Marshall C., III. "ACS.1: An Experimental Automated Command Support System," IEEE Transactions on Systems, Man, and Cybernetics, October 1978, pp. 725-735.

________. "Application of a Process Model to a Management Support System." Unpublished technical report, No. 9, Stanford Research Institute, Menlo Park CA, July 1974. AD 783544.

________. "The Schedulers of ACS.1." Unpublished technical report, No. 14, Stanford Research Institute, Menlo Park CA, September 1977. AD A046312.

________ and Daniel Sagalowicz. "Study of Automated Command Support Systems." Unpublished technical report, unnumbered, Stanford Research Institute, Menlo Park CA, 9 July 1979. AD A072298.

Phelps, Ruth H., Stanley M. Halpin, and Edgar M. Johnson. "A Decision Support Framework for Decision Aid Designers." Unpublished technical report, No. 504, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria VA, January 1981. AD A110329.

Pritsker, A.A.B., and L.J. Walters. A Zero-One Programming Approach to Scheduling with Limited Resources. Rand Document RM-5561-PR, Santa Monica CA, January 1968.

Ross, D.T., and others. "Integrated Computer-Aided Manufacturing (ICAM) Architecture Part II, Volume IV, Function Modeling Manual ($IDEF_0$)." Unpublished technical report, No. AFWAL-TR-81-4023, Volume IV, SofTech, Inc., Waltham MA, June 1981. AD B062457L.

Schoderbek, Charles G., Peter P. Schoderbek, and Asterios G. Kefalas. Management Systems: Conceptual Considerations. *Dallas: Business Publications, Inc., 1980.*

Sibley, Edgar H., and Alan G. Merten. "Implementation of a Generalized Data Base Management System Within an Organization." Unpublished research report, No. 59, University of Michigan, Ann Arbor MI, September 1972. AD 765538.

Sprague, Ralph H., Jr. "A Framework for the Development of Decision Support Systems," MIS Quarterly, December 1980, pp. 1-26.

Stewart, Captain John R., USAF. "An Analysis of the Effectiveness of the Jet Tanker Single Manager System." Unpublished research report, unnumbered, Air Command and Staff College, Maxwell AFB AL, 1965.

U.S. Department of the Air Force. B-52 Aircrew Training - Policy. SACM 51-52, Volume I. Headquarters Strategic Air Command, Offutt AFB NE, 7 April 1980.

________. Planning and Scheduling Aircrew and Aircraft Usage. SACR 60-9. Headquarters Strategic Air Command, Offutt AFB NE, 30 June 1980.

________. SAC Alert Procedures. SACR 55-43. Headquarters Strategic Air Command, Offutt AFB NE, 10 October 1979.

Wagner, G.R. "Decision Support Systems: Computerized Mind Support for Executive Problems," Managerial Planning, September/October 1981, pp. 9-16.

________. "Decision Support Systems: The Real Substance," Interfaces, April 1981, pp. 77-86.

Watkins, Paul R. "Perceived Information Structure: Implications for Decision Support System Design," Decision Sciences, January 1982, pp. 38-59.

York, Major Theodore R., USAF. "An Analysis of the SAC Centralized Scheduling Process." Unpublished master's thesis. Air Command and Staff College, Maxwell AFB AL, 1964.

Zalud, B. "Decision Support Systems - Push End User in Design/Build Stage," Data Management, January 1981, pp. 20-22.

B. RELATED SOURCES

Davis, M.W. "Resource Assignment and Management Information System for Event Scheduling in a Flight Training Environment," Interfaces, August 1980, pp. 68-73.

Drake, P., and W.H.P. Schmidt. "A Display System for High Level Decision Making." Unpublished research report No. STC PP-164, SHAPE Technical Center, The Hague, August 1979. AD B040488L.

Duncan, Captain William D., Jr., USAF, and Captain Curtis H. Gwaltney, USAF. "An Evaluation of the Effects of Selected Scheduling Rules on Aircraft Sortie Effectiveness." Unpublished master's thesis. LSSR 10-77A, AFIT/LS, Wright-Patterson AFB OH, June 1977. AD A044081.

Elam, Joyce J. "Model Management Systems: A Framework for Development." Unpublished technical report No. 79-02-04, University of Pennsylvania, Philadelphia PA, 12 February 1979, AD A067246.

French, Robert L. "Making Decisions Faster with Data Base Management Systems," Business Horizons, October 1980, pp. 33-36.

Goncz, Lieutenant Colonel Joseph Paul, USA. "The Data Base for Project Management Information Systems." Unpublished Research report, unnumbered, Defense Systems Management School, Ft. Belvoir VA, January 1975. AD A027571.

Grindley, A. "Decision Support Systems," Business Quarterly, Summer 1980, pp. 76-79.

Herot, Christopher F., and others. "Spatial Data Management System." Unpublished research report, unnumbered, Computer Corporation of America, Cambridge MA, 30 December 1980. AD A104255.

Honour, Craig Gibson. "A Computer Solution to the Daily Flight Schedule Problem." Unpublished master's thesis. Naval Postgraduate School, Monterey CA, June 1975. AD A012415.

Hurst, E.G., Jr., H.L. Morgan, and D.N. Ness. "DAISY: A Decision-Aided Information System." Unpublished research report No. 75-01-05, University of Pennsylvania, Philadelphia PA, 22 January 1975. AD A020647.

________, H.L. Morgan, and D.N. Ness. "Decision Aiding Information System (DAISY) User's Guide." Unpublished research report No. 75-01-02, University of Pennsylvania, Philadelphia PA, 22 January 1975. AD A-20646.

Leighton, R.T. "Decision Support Systems," Journal of Systems Management, Fall 1981, pp. 40-41.

Lenstra, J.K., and A.H.G. Rinnooy. "Complexity of Scheduling under Precedence Constraints," Operations Research, January 1978, pp. 34-51.

Marrs, First Lieutenant Danny D., USAF. "Automated Missile Operations Management System: Supplement No. 3 Batch Operation." Unpublished research report, unnumbered, 351st Strategic Missile Wing, Whiteman AFB MO, 15 January 1978.

Marsten, Roy E., Michael R. Muller, and Christine L. Killion. "Crew Planning at Flying Tiger: A Successful Application of Integer Programming." Management Science, December 1979, pp. 1175-1183.

Maxfield, M.W. "Sequencing and Scheduling in Real Time--Quickly," Interfaces, June 1981, pp. 40-43.

Miller, L.W. A Simple Adaptive Scheduling Mechanism for Planning Base Level Inspections. Rand Document R-938-PR, Santa Monica CA, February 1972.

Mulvey, J.M. "Strategies in Modeling: A Personnel Scheduling Example," Interfaces, May 1979, pp. 66-76.

Pannell, Major Carlton L., USAF. "A Linear Programming Application to Aircrew Scheduling." Unpublished master's thesis. U.S. Army Command and General Staff College, Ft. Leavenworth KS, June 1980. AD A092924.

Parrish, R.L. "Modernizing Crew Management," Airline Management and Marketing, Fall 1971, pp. 27-28.

Patterson, John F., L. Scott Randall, and Richard R. Stewart. "Advisory Decision Aids: A Prototype." Unpublished technical report No. PR-80-27-312, Decision and Designs Inc., McLean VA, February 1981. AD A098640.

Shapiro, Monroe. "Scheduling Crewman for Recurrent Training," Interfaces, June 1981, pp. 1-7.

Smith, L.D., and others. "Scheduling Personnel: Interactive vs Batch Processing," Journal of Systems Management, August 1977, pp. 28-32.

Sterpos, P. "Productivity, Work Force Availability and Rational Production Scheduling," Interfaces, August 1980, pp. 25-29.

Stott, Kenneth L., Jr., and Burnie W. Douglas. "A Model-Based Decision Support System for Planning and Scheduling Ocean-Borne Transportations," Interfaces, August 1981, pp. 1-18.

U.S. Department of the Air Force. B-52 Aircrew Training - Aircrew and Aircraft Operational Limitations/Restrictions. SACM 51-52, Volume VI. Headquarters Strategic Air Command, Offutt AFB NE, 10 December 1980.

________. B-52 Aircrew Training - Aircrew Training Devices Lesson Guides. SACM 51-52, Volume VII. Headquarters Strategic Air Command, Offutt AFB NE, 23 October 1980.

________. B-52 Aircrew Training - Continuation Training (Phase III). SACM 51-52, Volume IV. Headquarters Strategic Air Command, Offutt AFB NE, 20 March 1980.

________. B-52 Aircrew Training - Instructor Upgrade Training. SACM 51-52, Volume V. Headquarters Strategic Air Command, Offutt AFB NE, September 1979.

________. B-52 Aircrew Training - Mission Qualification Training (Phase II). SACM 51-52, Volume III. Headquarters Strategic Air Command, Offutt AFB NE, 5 May 1980.

Walsh, Major Robert P., USAF. "An Integrated Aircrew Training and Scheduling Program." Unpublished research study, Air Command and Staff College, Maxwell AFB AL, May 1977. AD B018587.

Weldon, Jay-Louise. "Data Storage Decisions for Large Data Bases." Unpublished doctoral dissertation, Decision Sciences Department, The Wharton School, University of Pennsylvania, Philadelphia PA, February 1976. AD A023874.

Woolsey, Gene. "An Optimum Scheduling, or Beer Trucks, Second Clarinets, and Carls," Interfaces, August 1980, pp. 11-15.

Yeh, Raymond T., and others. "Decision Support Systems: A Preliminary Study." Unpublished research report, unnumbered, University of Texas, Austin TX, September 1977. AD A108104.

BIOGRAPHICAL SKETCHES

Captain John M. Moore was commissioned in 1974 through Officer Training School. Afterwards he attended Undergraduate Navigator Training at Mather Air Force Base. He was selected for Electronic Warfare School and then assigned to the 28th Bombardment Wing, Ellsworth Air Force Base, after completing B-52 Combat Crew Training School. Here he upgraded to instructor and evaluator electronic warfare officer positions. He was then assigned to the B-52 Mission Development Branch as a scheduler and rapidly became the wing's Mission Development Branch Chief, prior to his Air Force Institute of Technology assignment. Captain Moore is a resident graduate of Squadron Officer School.

Captain Randall D. Whitmore was commissioned in 1974 through Officer Training School. Afterwards he attended Undergraduate Navigator Training at Mather Air Force Base. He was selected for KC-135 Combat Crew Training School and then assigned to the 55th Strategic Reconnaissance Wing, Offutt Air Force Base. Here he upgraded to instructor and evaluator navigator positions. In 1979, he was assigned to the wing command post as an officer controller where he rapidly became the wing's training officer for SAC Command Control Procedures, prior to his Air Force Institute of Technology assignment. Captain Whitmore is a resident graduate of Squadron Officer School.

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